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CONTRIBUTIONS TO JAPANESE ASCIDIAN FAUNA. V
ASCIDIANS COLLECTED NEAR THE MARINE BIOLOGICAL LABORATORY
OF HIROSIMA UNIVERSITY IN THE INLAND SEA (1)¹⁾²⁾

TAKASI TÔKIOKA

Seto Marine Biological Laboratory, Sirahama

With 16 Text-figures

Many specimens of ascidians have been collected by Prof. IWAÔ TAKI of Hirosima University in the neighbourhood of the Marine Biological Laboratory of the University. The laboratory is situated on the south-west coast of Mukô-zima, a large island opposite the town of Onomiti near Hirosima. These specimens were offered me for examination by the courtesy of Prof. TAKI, to whom I express here my hearty thanks for his kindness. I have finished to examine a part of them and give some notes in the following.

1. *Didemnum (Didemnum) tigrinoides* n. sp.

(Fig. 1)

A small colony, 24 mm × 10 mm in extent and 1 mm in thickness. The surface of the colony shows a complex pattern consisting of wider dark brownish areas and narrower yellowish-white areas. The former is the part containing zooids beneath, while the latter is the part covering the well-developed cloacal lacunae system.

Spicules: Calcareous spicules are distributed as shown in Fig. 1-2. They are found around the thorases of zooids, most densely near the neck region, and in the covering layers and the bottom layers of cloacal canals. Spicules around the zooids are completely concealed superficially by pigment cells in the surface layer. Large spicules 50-75 μ in diameter, with ca. 13 rays on the equatorial plane. Rays not thick, pointed acutely at the tip.

1) A part of the study promoted by the financial aid from the Ministry of Education.

2) Contributions from the Seto Marine Biological Laboratory, No. 198.

Zooid: Thorax ca. $360\ \mu$ in length in contracted state. Abdomen ca. $430\ \mu$ and neck considerably long. Branchial aperture 6-lobed. Retractable muscle short. Atrial aperture as in *Did.* (*Did.*) *moseleyi* (HERDMAN)?; its accurate appearance is quite unknown, because of the strong contraction of the body. Alimentary canal courses as in common species of the subgenus *Didemnum*. No gonad is found in any zooid examined.

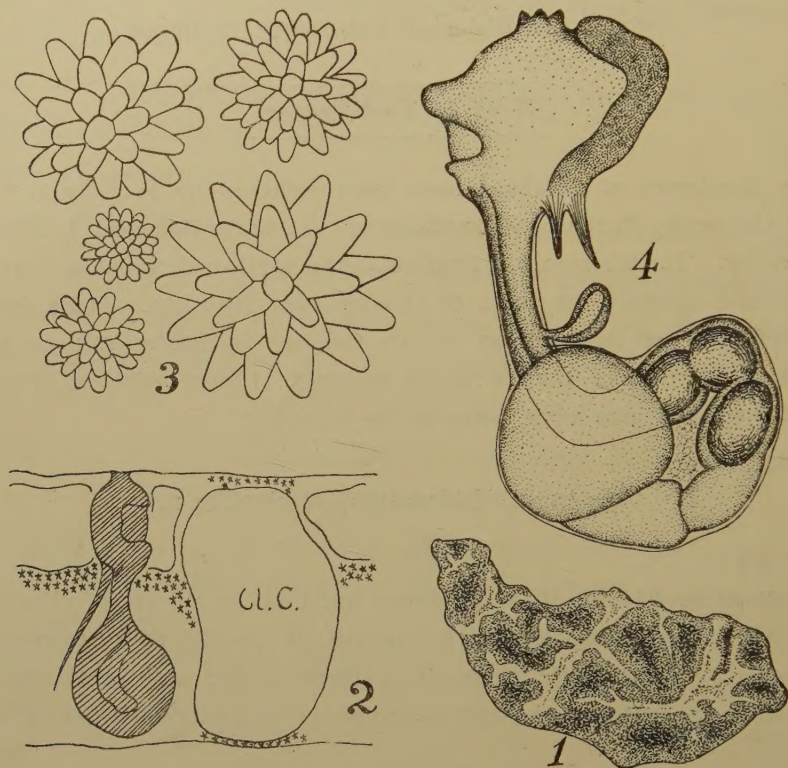


Fig. 1. *Didemnum* (*Didemnum*) *tigrinoides* n. sp. 1—Colony, $\times 2$; 2—A schema representing a section of the colony; 3—Calcareous spicules, $\times 440$; 4—Zooid, $\times 70$.

Remarks: The present species resembles superficially *Did.* (*Did.*) *areolatum* TOKIOKA and *Didemnoides tigrinum* OKA (MS.) in Figuraro de Japanaj Bestoj (1927, p. 498, Fig. 960), the latter of which is revealed by the re-examination of the type specimen to be a species of the genus *Leptoclinides*. *Did.* (*Did.*) *areolatum* differs distinctly from the present species in having much smaller calcareous spicules, less than $34\ \mu$ in diameter, with merely 6–8 rays on the equatorial plane and distributed evenly throughout the colony from the surface

to the bottom. *Did.* (*Did.*) *partitum* TOKIOKA is related to the present species in that it has large calcareous spicules in the test, although they have each usually merely 6-8 rays on the equatorial plane instead of ca. 13 in the present new species. For convenience to record the material, I prefer to name provisionally the present specimen *Did.* (*Did.*) *tigrinoides* on its superficial resemblance to *Didemnoides tigrinum* OKA (MS.).

2. *Ciona intestinalis* (LINNAEUS), 1767

(Figs. 2 and 3)

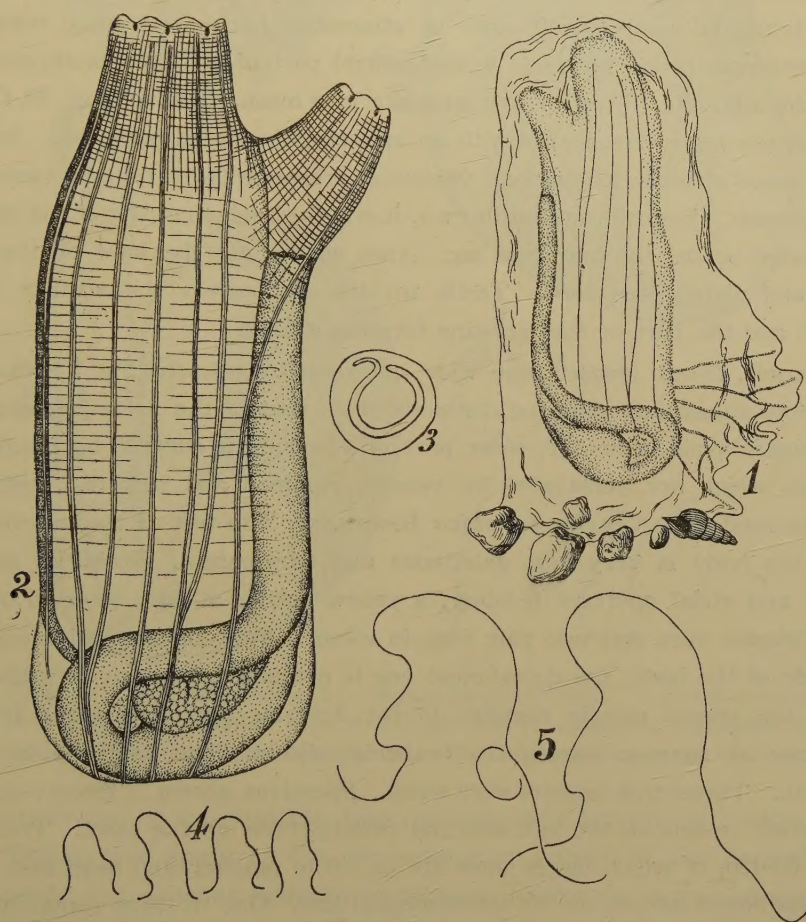


Fig. 2. *Ciona intestinalis*. (L.) 30 mm long individual. 1—Entire animal, 2—Mantle body from left side, 3—Ciliated groove, enlarged; 4—Supporting papillae of the inner longitudinal vessel, $\times 70$; 5—Supporting papillae of the inner longitudinal vessel of a large specimen collected at Uwazima, Sikoku. $\times 70$.

As an example, a finely preserved 30 mm long individual (Fig. 2) was dissected for description. Test soft, gelatinous and transparent. There are many processes near the posterior end of the body, by which the animal attached to the substratum or to gravels or shell fragments. These processes are pierced through with vessels. Branchial aperture terminal and 8-lobed, atrial aperture slightly behind the branchial aperture and 6-lobed. Seven longitudinal muscles on each side of the body, the dorsal-most one of which runs anteriorly into the atrial siphon, while others go into the branchial siphon. The ventral-most muscle is very thin. These muscles are united into 5 bundles near the posterior end of the body on each side. Twenty-two inner longitudinal vessels on each side of the branchial sac; ca. 60 rows of stigmata. Large and small transverse vessels alternate rather regularly in the central part of the sac; small ones pass across the stigmata. Four to five stigmata in a mesh. Tentacles ca. 30. Ciliated groove simple horse-shoe-shaped with an arm slightly curled outwards. Supporting processes of inner longitudinal vessels at crosses with transverse vessels are rather slender. Stomach orange brown, it and the beginning part of the intestine are situated behind the branchial sac. Anus opens near the base of the atrial siphon and plainly margined. Testis whitish and covers the surface of the stomach and the part of the intestine forming a loop.

A larger, 45 mm long $\times$ 30 mm wide, contracted specimen (Fig. 3) was found in a curious appearance differing distinctly from that of the preceding specimen. It is roughly ovoid in outline, most part of the body is covered by many small processes which are penetrated by vessels, ramified and carrying many sand grains or mud as in *Corella japonica* HERDMAN. The test of the anterior $1/3$ – $1/4$ of the body is very soft, gelatinous and transparent. Branchial aperture 8-lobed and atrial aperture 6-lobed; a yellow ocellus at each interval between lobes. Mantle very soft and pale flesh in colour. Five longitudinal muscles on each side of the body, the dorsal-most one is extended anteriorly into the atrial siphon, the second muscle ramified in the anterior part into three branches which are all running toward the branchial siphon. The ventral-most one is very thin. Transverse muscles very weak. Plications absent. Twenty-six inner longitudinal vessels on the left side and twenty-three on the right. Transverse vessels 80–120, of which larger ones are ca. 40 in number and bear each a long triangular dorsal languet on the dorso-median line. One to three (small-medium-small) thinner transverse vessels between a pair of thicker ones. Parastigmatic vessels present. Eight~ten stigmata in a mesh. Supporting papillae of inner longitudinal vessels are very broad. Tentacles 50–60. Dorsal tubercle situated at just the anterior end of the dorsal ganglion. Ciliated groove inverted Ω -shaped.

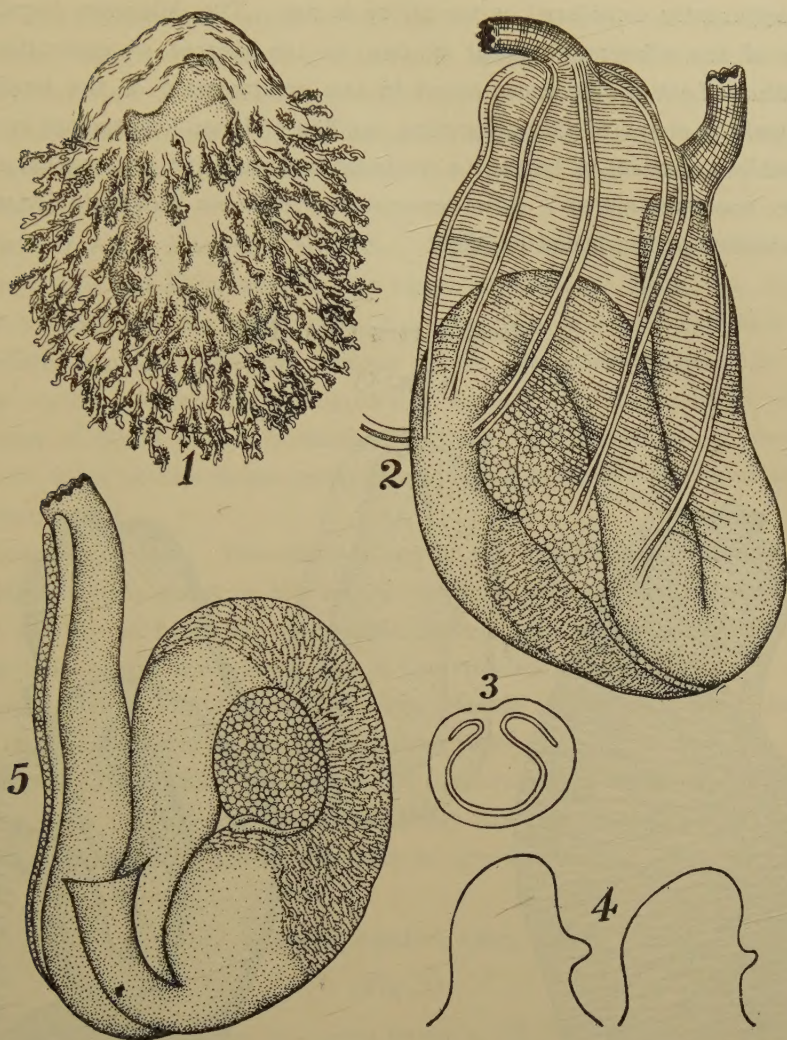


Fig. 3. *Ciona intestinalis* (L.) 45 mm long individual. 1—Entire animal, 2—Mantle body from left side, 3—Ciliated groove, enlarged; 4—Supporting papillae of the inner longitudinal vessel, $\times 70$; 5—Alimentary canal, right side.

The anterior end of the intestinal loop reaches fairly beyond the middle of the body. Oesophagus opens at the dorso-posterior corner of the branchial sac, consequently the globular stomach is situated behind the branchial sac. Anus irregularly lobed. Ovary in the intestinal loop. Testicular follicles are spread over the surface of the intestinal wall.

Remarks: There are many distinct differences between two specimens, as mentioned above. Differences found in number of the vessels of the branchial

sac are apparently considered as variations in age. The difference found in the situation of the alimentary canal is due to the degree of contraction after preservation. Lastly, differences found in the arrangement of the longitudinal muscles and the shape of the supporting papillae of inner longitudinal vessels of the branchial sac seem to belong to the individual variation, although at a glance the larger specimen shows a close resemblance to *Ciona pulchella* (ALDER)* in the appearance of the broad papillae.

3. *Ascidia zara* OKA, 1935

(Fig. 4)

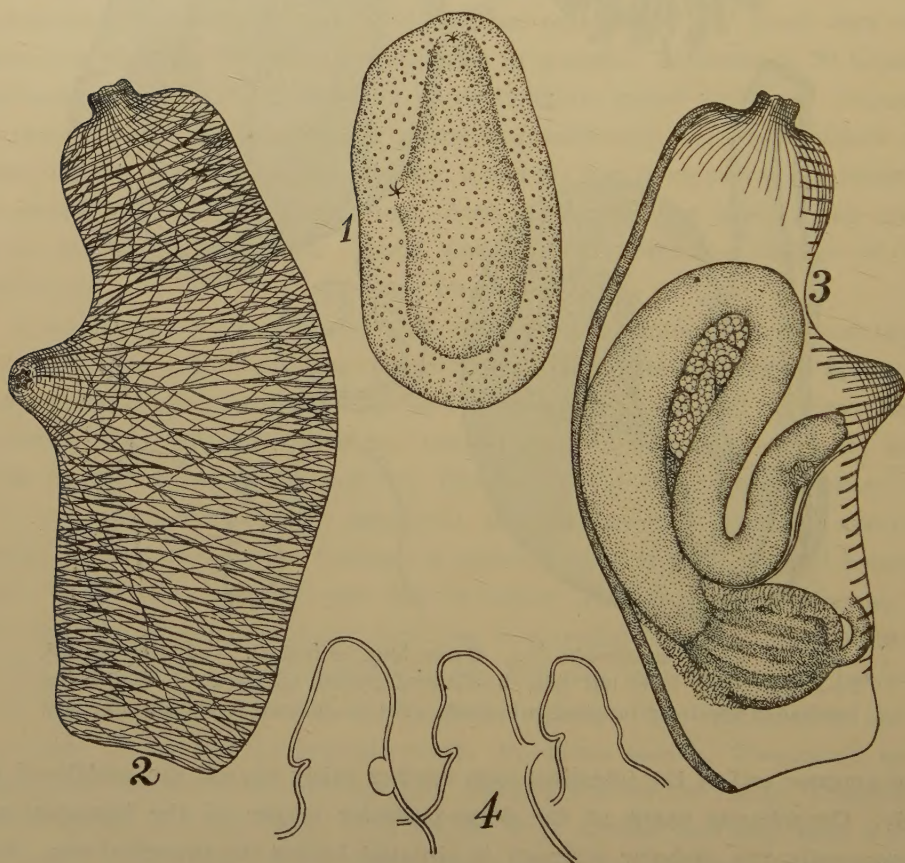


Fig. 4. *Ascidia zara* OKA. 1—Entire animal, from right side; 2—Mantle body from right side, 3—Mantle body from left side, 4—Supporting papillae of inner longitudinal vessels, $\times 70$.

* ALDER & HANCOCK (1927): The British Tunicata, Vol. II, pp. 14-15, Pl. I figs. 6-8.

A 40 mm×32 mm individual in the material, elongate oval in outline and having many hairy processes on the left side, along this side the animal lies on the muddy bottom. Both apertures sessile, the branchial aperture terminal and 7-lobed, and the atrial aperture situated near the middle of the body and 6-lobed. The musculature on the right side of the mantle body consists mainly of transverse muscles.

Branchial sac: Plications present. Thirty-two inner longitudinal vessels on the left side and 35 vessels on the right. Transverse vessels ca. 90 on the left side and 105 on the right; they are arranged as—thick-thin-thick-thin—. Intermediate papillae found in various places, especially abundantly in the posterior portion. Seven to ten stigmata in a mesh. Tentacles ca. 50, excluding minute ones of about the same number. Ciliated groove shallow U-shaped and situated in front of the dorsal ganglion about the length of the ganglion apart. Dorsal lamina tall.

Alimentary system: The anterior end of the intestinal loop reaches beyond the atrial aperture about a 1/3 of the distance between both siphons. Anus situated slightly in front of the middle of the loop. The axis of the second intestinal loop passes the pyloric end of the stomach.

Gonad: Ovary in the intestinal loop. Testis pinkish, covering the whole surface of the alimentary canal on the inner side.

Remarks: Differences found between the present specimen and others described by OKA (1935) and TOKIOKA (1953) are all considered as individual variations or differences due to the state of preservation.

4. *Ascidia ahodori* OKA, 1927

(Fig. 5)

OKA, A. (1927) in: *Figuraro de Japanaj Bestoj*, p. 493, Fig. 950.

Two individuals in the collection, each 35 mm in length. Body roughly oval in outline, 24 mm wide and 8 mm thick, and attached to the substratum by the whole left side. Branchial aperture terminal and 7-lobed, atrial aperture situated at the 1/3 of the body length from the anterior end of the body and 6-lobed. Both apertures sessile.

Test: Rather thick, cartilaginous, translucent and yellowish-white in colour. The surface smooth and quite free from foreign matters. Vessels running through the test are thin; their terminals are not swollen.

Mantle: Yellowish brown. The right side covered thoroughly with delicate muscles. Both siphons short. Atrial siphon situated at the middle of the mantle body.

Branchial sac: Plications present. Inner longitudinal vessels 38-45 on each side at the middle part of the sac. Transverse vessels 140-149 on the left side; they are arranged as 1 4 3 4 2 4 3 4 1..., here numerals represent the order of the thickness. Four to five stigmata in a mesh. Supporting papillae of inner

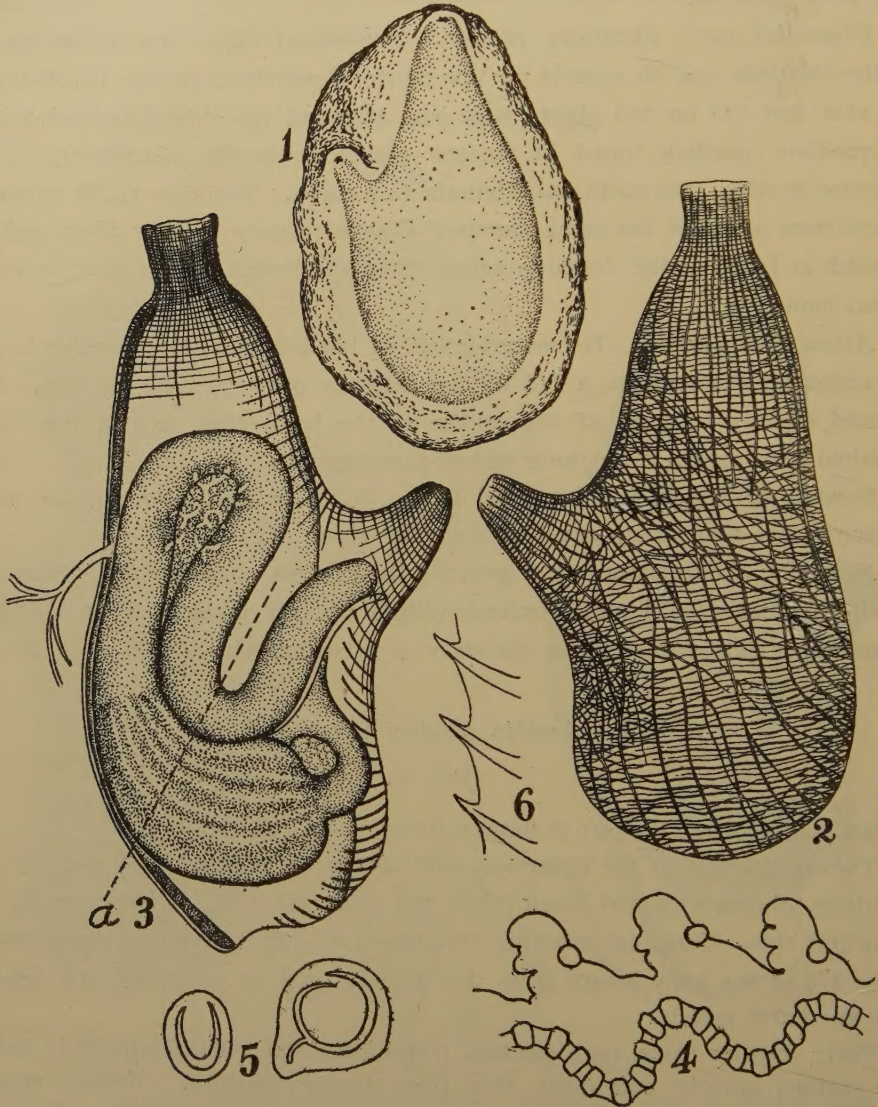


Fig. 5. *Ascidia ahodori* OKA. 1—Entire animal from right side, 2—Mantle body from right side, 3—Mantle body from left side, 4—Supporting papillae of inner longitudinal vessels, $\times 70$; 5—Dorsal tubercles, enlarged; 6—A part of dorsal lamina. *a*—Axis of the second intestinal loop.

longitudinal vessels have each a distinct prominence on the dorsal margin. Tentacles 42-50 including large and small ones. The dorsal tubercle situated in front of the dorsal ganglion about 2-3 times the length of the ganglion apart. Ciliated groove simple U-shaped. Dorsal lamina ribbed, distal ends of ribs protrude beyond the margin of the lamina.

Alimentary system: The anterior end of the intestinal loop reaches beyond the atrial aperture about a third of the distance between the bases of both siphons. Anus is situated at the $1/3$ of the visceral mass from the anterior end of the intestinal loop and plainly margined. Oesophagus opens to the branchial sac about a $1/3$ of the length of the sac from the posterior end. The axis of the second intestinal loop passes through the stomach about $1/3$ to $1/2$ of its length from the pyloric end. Stomach large, elongate oval and faintly striated. Gonad immature.

Remarks: I considered, at first, that the present specimens represent young individuals of *As. longistriata* HARTMEYER which differs, however, distinctly from the former in the following three points: 1)---Transverse vessels of the branchial sac less than 120 in individuals as long as these specimens, 2)---Stomach small and globular in outline, 3)---Found previously only from the deep waters. Next, *As. matoya* TOKIOKA resembles closely the present species in the appearance of the mantle body; the former shows, however, a characteristic appearance of the body covered externally with many hairy processes which hold muddy sand on the surface. *As. ceratodes* (HUNTSMAN) from the western coast of North America is also related to the present specimens. This American species is, however, provided with much more tentacles, 150-200 ones instead of ca. 50 in the latter.

The original description given by OKA (1927) for *As. ahodori* is only brief and imperfect, as follows:—

“Body elongate oval in outline, considerably flattened laterally, 40 mm long $\times$ 22 mm wide, and attached to the substratum by the left side. Branchial aperture terminal and 8-lobed, atrial aperture situated at $1/3$ of the body length from the branchial aperture and 6-lobed. Both apertures sessile. The surface of the test is almost smooth and free from foreign matters. A few root-like protuberances are issued from the margin of the body. Test soft cartilaginous, translucent and pale yellowish in colour. Mantle thin; the right side with musculature, while the left side is devoid of muscle and quite transparent. Intestine forms double loops on the left side. Loc.: Along the coasts of Hokkaidô, Honsyû and Sikoku.”

From the figure given by OKA, the following point may be accepted that

the atrial siphon is situated at the middle of the mantle body. Details of the branchial sac and the arrangement of the alimentary canal are quite unknown. I have searched the type specimen of this species to reexamine carefully the internal structure of the animal, but I have not been able to find it at any place nor specimen labelled as *As. ahodori*, except one in the material in the Biological Laboratory in the Imperial Palace. The only single specimen identified by OKA as *As. ahodori* was, unfortunately, dried completely and consequently I could not ascertain whether the specimen represented a young, ca. 30 mm long, individual of *As. longistriata* or an independent species. The locality, Amadaiba 60 fathoms in Sagami Bay, seems rather to emphasize the idea that the specimen belongs to *As. longistriata*, a deep-sea ascidian. Notwithstanding these circumstances, I prefer to call the present specimen *Ascidia ahodori* by the following reasons: 1) —The present specimens fit to the brief descriptions given by OKA, 2) —*As. ahodori* seems to be widely distributed along Japanese coasts. I intend to use in future the name *Ascidia ahodori* for specimens which show characteristics indicated in the description given above.

5. *Ascidia alpha* n. sp.

(Fig. 6)

Two 35 mm long individuals are attached to the substratum side by side. The body roughly oval in outline. Branchial aperture terminal and 7-8 lobed, atrial aperture situated slightly behind the branchial and 6-lobed.

Test: Cartilaginous, translucent and milky-white in colour. The surface is smooth and free from foreign matters, although it is slightly coarse to the touch.

Mantle: Yellowish brown. Atrial siphon fairly long and situated at 1/4-1/3 of the body length from the anterior end of the body. The right side is wholly covered by muscles.

Branchial sac: Plications found in contracted parts. Inner longitudinal vessels 40-50 on each side, transverse vessels 132-133 on the right side. Six to eight thinner vessels between each pair of thicker ones. Supporting papillae of inner longitudinal vessels not so long. Four to five stigmata in a mesh. Tentacles ca. 60, including large and small ones. Ciliated groove nearly circular, interrupted anteriorly. Dorsal tubercle situated in front of the dorsal ganglion about a half of the length of the tubercle apart. Dorsal lamina as in the preceding species.

Alimentary system: The anterior end of the intestinal loop never reaches beyond the base of the atrial siphon. Anus situated near the anterior end of the loop, the margin is thickened but not lobed. Oesophagus opens to the branchial

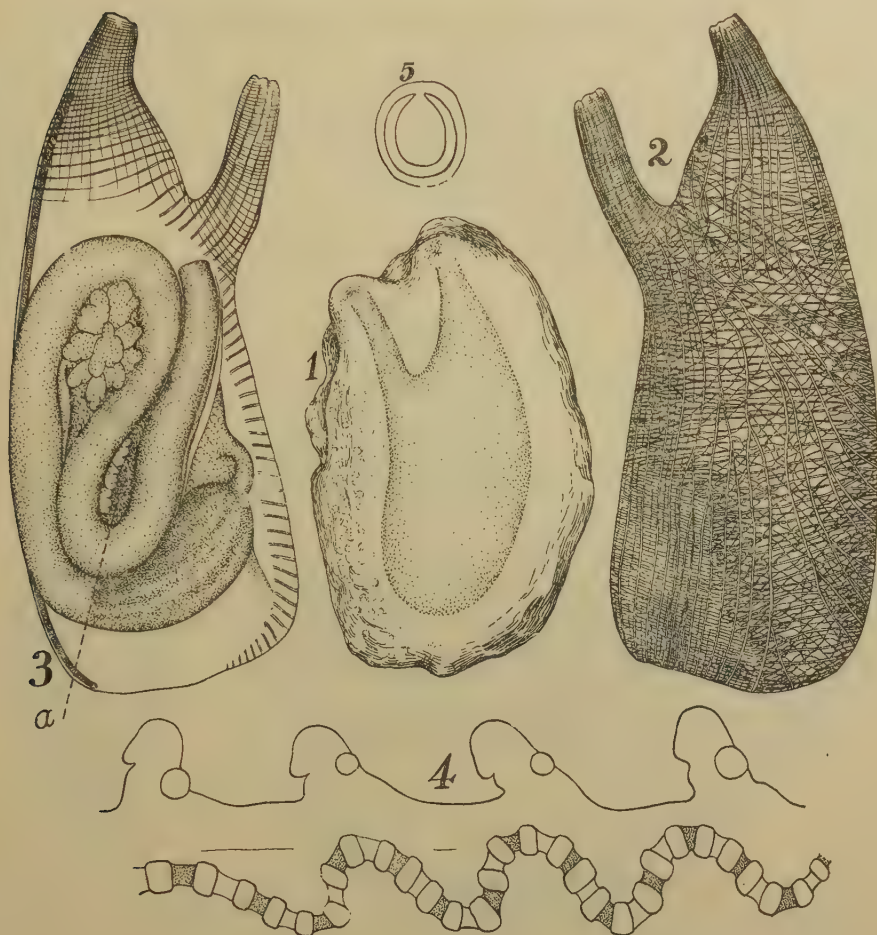


Fig. 6. *Ascidia alpha* n. sp. 1—Entire animal from right side, 2—Mantle body from right side, 3—Mantle body from left side, 4—Supporting papillae of inner longitudinal vessels, $\times 70$, 5—Dorsal tubercle, enlarged. a—Axis of the second intestinal loop.

sac at about $1/3$ of the length of the branchial sac from the posterior end. The axis of the nearly closed second intestinal loop passes the pyloric end of the stomach which is elongate oval in shape.

Gonad: As in common species of *Ascidia*.

Remarks: The present species differs from the preceding species in the position of the atrial siphon and in the arrangement of the alimentary canal.

6. *Botryllus communis* OKA, 1927

A thin, ca. 1 mm thick, colony. Systems consist each of 4-9 zooids. Zooids, vessels and bulbs are all dark purplish in colour.

7. *Botrylloides violaceum* OKA, 1927

(Fig. 7)

Colonies dark purplish or reddish brown in colour and may reach ca. 5 mm in thickness. Stomach with 8-9 plications, most frequently with 9 plications. Prof. TAKI alludes in his letter to me to the probability that this compound ascidian is food for *Erato callosa* ADAMS et REEVE.

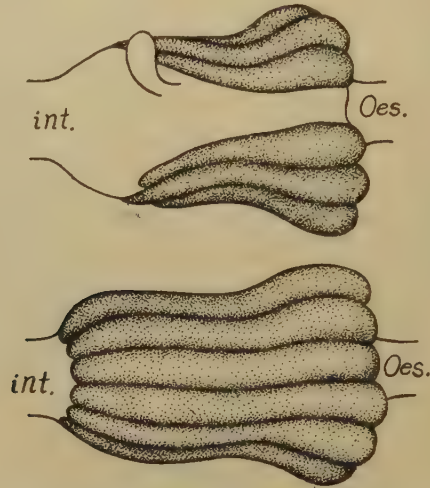


Fig. 7. *Botrylloides violaceum* OKA. Stomach, enlarged.
oes.—oesophagus, int.—intestine.

8. *Symplegma connectens** TOKIOKA, 1949

(Fig. 8)

A spatulate colony in the material. It is 45 mm long $\times$ 15 mm wide $\times$ 7 mm thick, dark purplish brown in colour and embraces a flat object as an axis. Zooids slightly oblique and occupy the whole surface of the colony.

Branchial sac: Ten~eleven (or more) rows of stigmata. Parastigmatic vessels found very sparsely. Stigmata arranged between 4 inner longitudinal vessels as follows:

D. 6 (1) 4-5 (1) 4-5 (1) 4 (1) 6 V.

Tentacles about a dozen. Dorsal lamina a plain membrane.

Alimentary system: The anterior end of the intestinal loop may reach slightly beyond the 7th transverse vessel. Anus situated at the 5th transverse vessel and plainly margined. The axis of the second intestinal loop passes the

* I revise here the former name *connectans* to *connectens* on the kind advice of Prof. TAKI.

oesophagus. Stomach large, globular and with ca. 13 longitudinal plications on the surface. Pyloric coecum practically absent. A thick vessel connecting the anterior pyloric corner of the stomach to the intestine.

Gonad: Ovaries and testes in the same arrangement as in *Symplegma reptans*. Testis consists of two testicular lobes which are usually divided each into two lobules.

Larva: 1.3-1.7 mm in length. The structure is quite the same as in *Sym. reptans*.

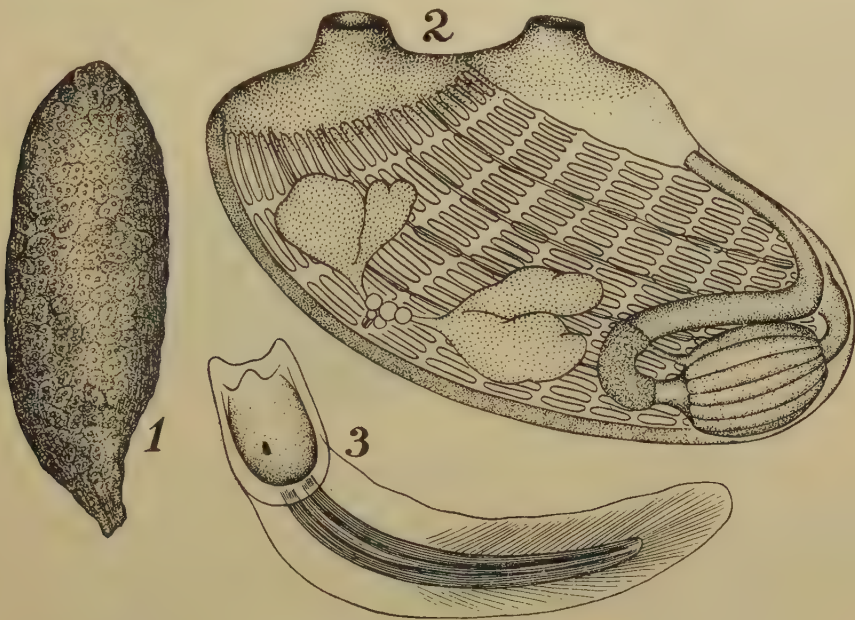


Fig. 8. *Symplegma connectens* TOKIOKA. 1—Colony, $\times 1.5$;
2—Zooid from left side, much enlarged; 3—Larva, $\times 45$.

Remarks: I indicated in my previous paper (1949) 4 characteristics differentiating the present species from *Sym. reptans*, 2 of which seem, however, to be withdrawn. The remaining two characteristics are common to the present specimen and that described in my previous paper; they are: 1)—Rows of stigmata are more numerous in *Sym. connectens* than in *Sym. reptans*, 2)—Stomach with more numerous plications in *Sym. connectens* than in *Sym. reptans* and has merely a connecting vessel in the former in place of a pyloric coecum in the latter.

Diandrocarpa brakenhielmi MICHAELSEN var. *ceylonica* HERDMAN resembles closely the present species in the number of the rows of stigmata (10-12), but it differs distinctly from the latter in having a distinct pyloric coecum.

9. *Cnemidocarpa areolata* (HELLER), 1878

(Fig. 9)

Three specimens, 22-24 mm long, in the collection. Test whitish, atrial aperture situated at the middle of the body or slightly anterior to it. About 25 large atrial tentacles are found in the 23 mm long individual.

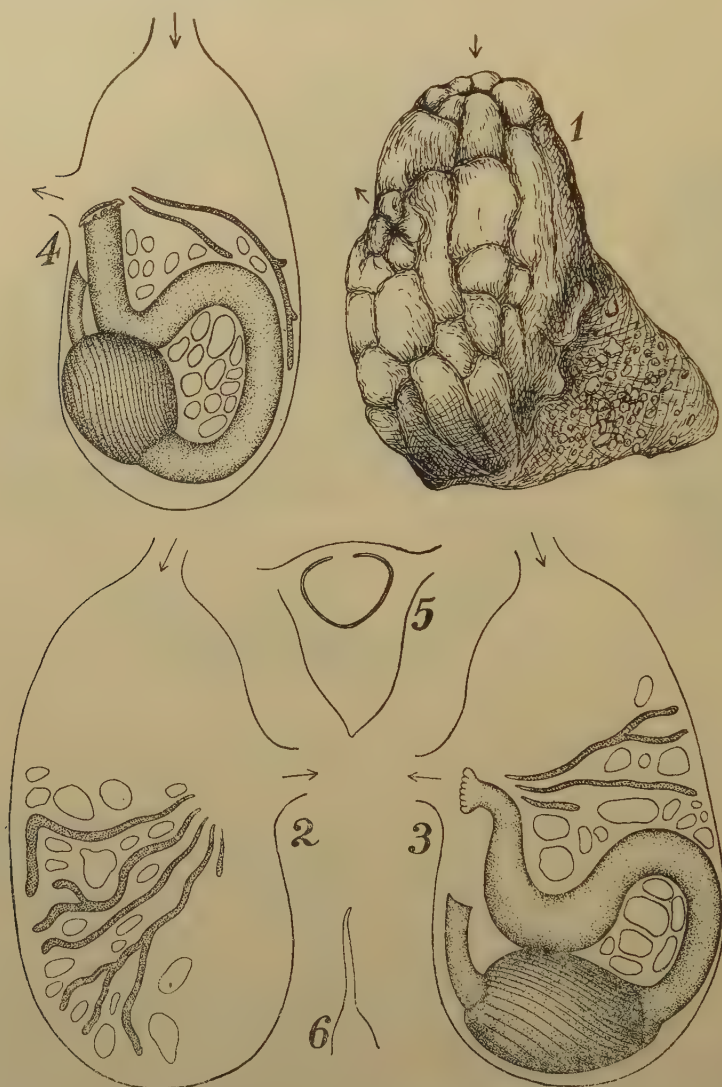


Fig. 9. *Cnemidocarpa areolata* (HELLER). 1-3, 5-6—23 mm long individual; 4—24 mm long individual. 1—Entire animal from right side, 2—Mantle body, right half from inside; 3, 4—Mantle body, left half from inside; 5—Dorsal tubercle, magnified. 6—Atrial tentacle, magnified.

Branchial sac: Inner longitudinal vessels arranged in the 23 mm long individual as follows:

Left	D.	0	(12)	3	(13)	3	(13)	3	(9)	3	V.
Right	D.	0	(12)	3	(13)	3	(13)	3	(10)	3	V.

Transverse vessels arranged as—thick-thin-medium-thin-thick—. Parastigmatic vessels present in most part. Usually 5-7 stigmata in a mesh, although they may reach 10 in some wide meshes. Tentacles ca. 25 including minute ones in the 23 mm long individual.

Alimentary system: The axis of the second intestinal loop passes the middle of the stomach which is provided with 10-15 longitudinal plications on each side. Seven~thirteen endocarps in the first intestinal loop. Pyloric coecum absent.

Gonad:

22 mm long individual.....	Left	2	Right	6
23 mm long individual.....	„	3	„	5
24 mm long individual.....	„	2	„	4

Remarks: These specimens are related more closely to those reported by HERDMAN (1906) from Ceylon than to those reported by VAN NAME (1918) from the Philippine waters in the number of gonads.

10. *Cnemidocarpa macrogastra* (OKA), 1935

Two specimens in the collection; they are respectively 27 mm and 17 mm in length. The former is ca. 10 mm in thickness (laterally). Test milky white to yellowish white. Mantle yellowish white. Inner longitudinal vessels of the branchial sac arranged as follows:—

17 mm long individual

Left	D.	3	(17)	3	(10)	3	(15)	3	(10)	2	V.
Right	D.	2	(20)	3	(13)	3	(12)	3	(9)	2	V.

27 mm long individual

Left	D.	1	(19)	2	(15)	1	(16)	3	(10)	3	V.
Right	D.	1	(20)	2	(16)	2	(15)	2	(10)	2	V.

Transverse vessels arranged as: thick-thin-medium-thin-thick—. Stigmata in a mesh usually 6-7, although they may reach ca. 10. Tentacles 28-35, including minute ones. Dorsal lamina plainly edged or partially serrated. Stomach very long occupying 3/4 of the ventral branch of the first intestinal loop. About seven endocarps in the first intestinal loop.

Gonad:

27 mm long individual.....	Left	7	Right	8
17 mm long individual.....	„	6	„	8

Remarks: These specimens are figured in "Ascidians of Sagami Bay" in Text-fig. 18, p. 122.

11. *Styela partita* (STIMPSON), 1852

(Fig. 10)

Four specimens in the material. They are 15 mm-22 mm in length. Body

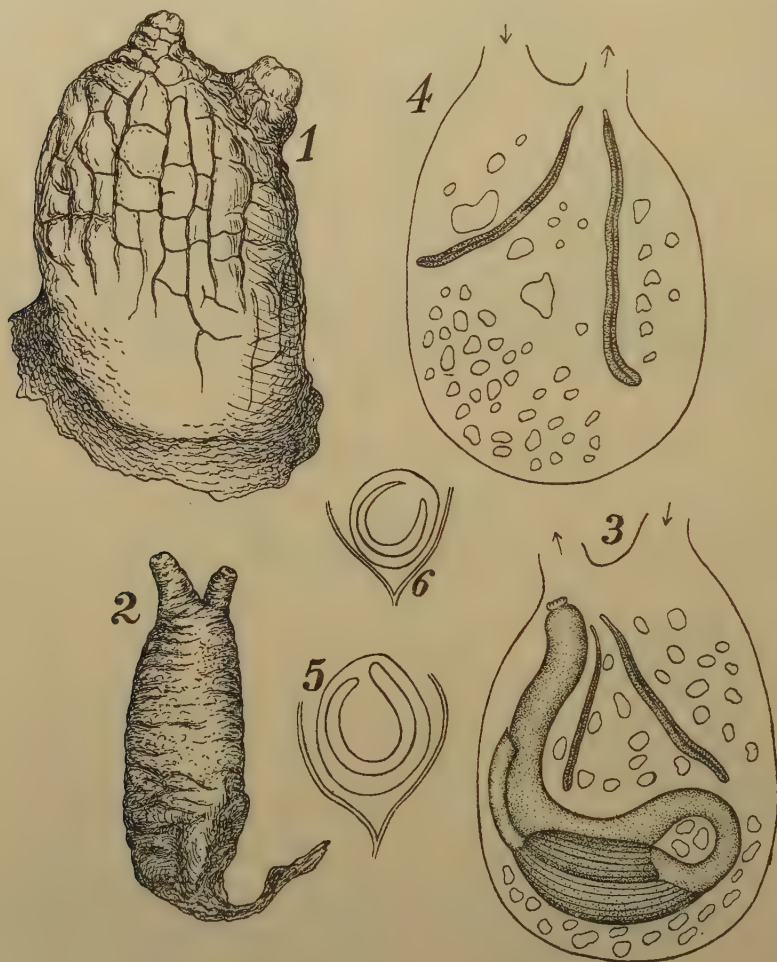


Fig. 10. *Styela partita* (STIMPSON). 1—22 mm long individual from left side, 2—15 mm long×6 mm wide individual, 3—Mantle body of 22 mm long individual, left half from inside; 4—Mantle body, right half from inside; 5—Dorsal tubercle of 22 mm long individual, 6—Dorsal tubercle of 20 mm long individual.

roughly oval, attached to the substratum by the right posterior side. Branchial aperture terminal, atrial aperture subterminal. Both siphons short but distinct. Two of the four specimens are very elongate, respectively 20 mm long×8 mm wide and 15 mm long×6 mm wide (Fig. 10-2). They are attached by the posterior end and each provided with both siphons at the anterior end of the body. Test yellowish white, leathery; the surface is grooved irregularly and in the anterior half it is divided roughly into many small quadrate areas.

Branchial sac: Inner longitudinal vessels are arranged in the 22 mm long individual as follows:

Left D. 1 (19) 3 (13) 3 (17) 3 (15) 2 V.

Right D. 1 (18) 4 (16) 4 (15) 4 (13) 2 V.

Transverse vessels arranged as thick-thin-medium-thin-thick—. Parastigmatic vessels present, four to six elongate stigmata in a mesh. Tentacles less than 46 in number, large and small ones alternate regularly. Ciliated groove simple U or C-shaped.

Alimentary system: Alimentary canal figures a S-shaped course in the posterior half of the body. The axis of the wide second intestinal loop passes the oesophagus. The stomach rather large, nearly horizontal and provided with ca. 30 longitudinal plications on the surface. Anus finely lobed.

Gonad: Two on each side. They are all immature.

12. *Styela clava* HERDMAN, 1881

(Fig. 11)

Two small specimens, each 17 mm long×5.5 mm wide. Body elongate cylindrical, attached to the substratum by the posterior end. Both apertures 4-lobed and open on short siphons situated at the anterior end of the body; the atrial siphon slightly anterior to the branchial. Test thin, translucent and yellowish-white in colour. The surface nearly smooth, with only a few faint wrinkles. Mantle adheres firmly to the test. There are many endocarps on the inner surface of the mantle, of which those near the posterior end of the body are much larger than others.

Branchial sac: Inner longitudinal vessels arranged as:—

Left D. 2 (11) 2 (9) 2 (10) 3 (7) 2 V.

Right D. 3 (11) 3 (9) 3 (11) 3 (8) 3 V.

Transverse vessels arranged as:—thick-thin-medium-thin-thick—, or thick-parastigmatic vessel-thick—; parastigmatic vessels intervene between some vessels

in the former case. Four to six stigmata in a mesh, they may be ca. 10 in meshes along the endostyle and the dorsal lamina. Stigmata comparatively large and elongate in form. Tentacles ca. 30 excluding minute ones. Ciliated groove C-shaped, opened anteriorly.

Alimentary system: Stomach descending, about half as long as the ascending branch of the intestine, and provided with ca. 30 longitudinal plications on the surface and a small pyloric coecum. Rectum swollen remarkably along a considerable length. Anus finely lobed.

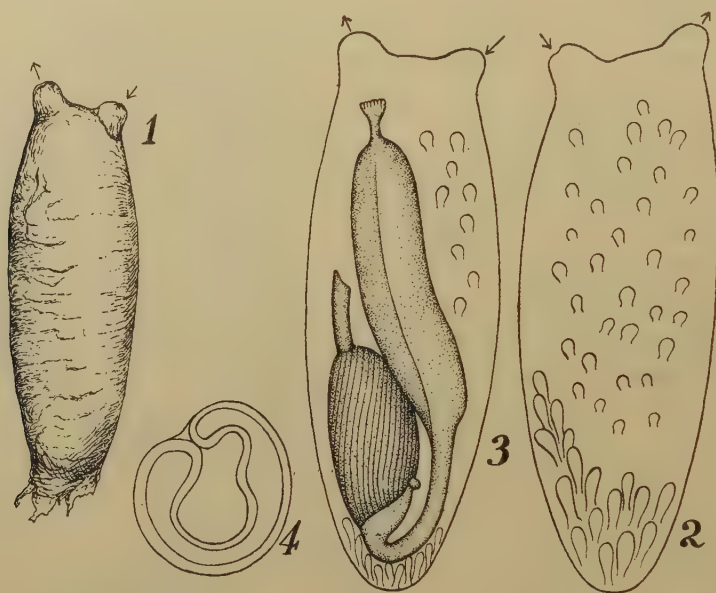


Fig. 11. *Styela clava* HERDMAN. 1—17 mm long individual from right side, 2—Mantle body, right half from inside; 3—Mantle body, left half from inside; 4—Dorsal tubercle, magnified.

Gonad: Quite immature.

Remarks: The external appearance of these specimens differs fairly from the general appearance of young individuals of *St. clava* in the following features: 1)—Test rather thin and translucent, 2)—The neighbourhood of siphons is quite devoid of irregular protuberances found characteristically in *St. clava*. I prefer, however, to treat these specimens as young individuals of *St. clava*, since the internal structure of these specimens conforms well to that of the typical forms of this species, excepting the swollen appearance of the rectum.

13. *Pyura lepidoderma* TOKIOKA, 1949

(Fig. 12)

This species seems to be rather common in the vicinity of the Laboratory. Two specimens were dissected for descriptions. They are respectively 13 mm long $\times$ 13 mm wide and 12 mm long $\times$ 9 mm wide and attached to the substratum by the left side. Test cartilaginous, 1.5–2 mm in thickness and yellowish-white in colour. The surface is divided into a number of polygonal areas by many conspicuous crests and assumes an appearance as if it were covered with many scales. Branchial aperture subterminal at the anterior end of the body and surrounded by 6 small areas, atrial aperture subterminal at the posterior end and with 4 small marginal areas.

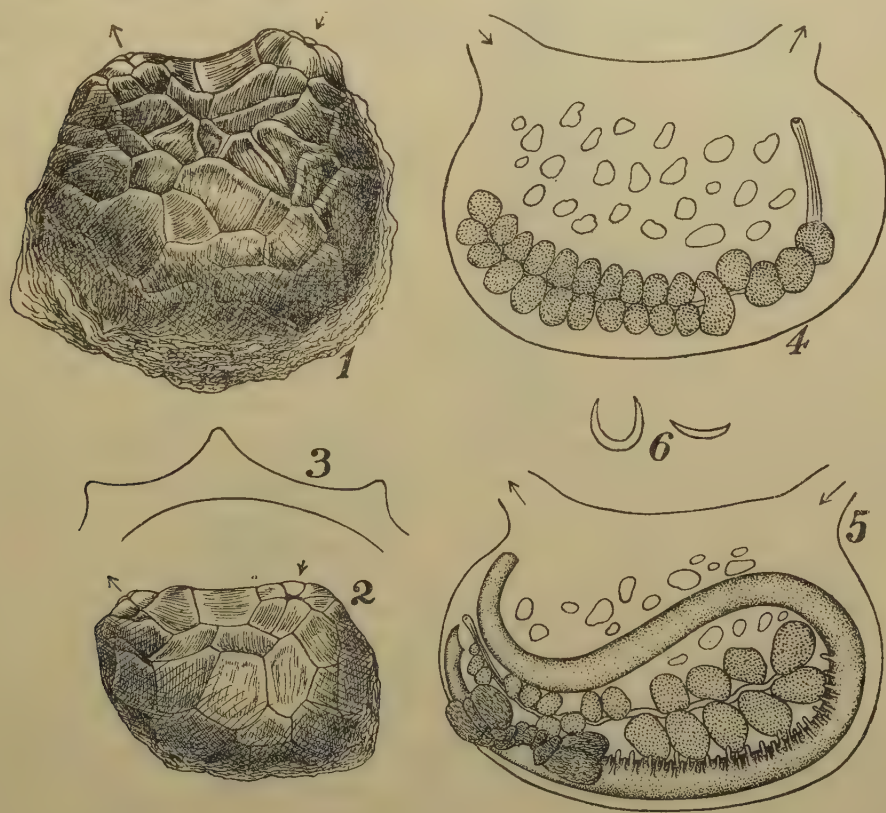


Fig. 12. *Pyura lepidoderma* TOKIOKA. 1—13 mm long individual from right side, 2—12 mm long individual from right side, 3—Section of test, enlarged; 4—Mantle body, right half from inside; 5—Mantle body, left half from inside; 6—Ciliated grooves, magnified.

Mantle: Thin and with coarse musculature consisting of muscles arranged regularly in cross stripes. Many endocarps on the inner surface.

Branchial sac: Inner longitudinal vessels arranged as follows:—

13 mm long specimen

Left D. 1 (10) 2 (8) 2 (12) 2 (13) 2 (11) 2 (6) 2 V.

Right D. 1 (12) 2 (10) 2 (14) 2 (13) 2 (11) 2 (6) 2 V.

Thick and thin transverse vessels alternate rather regularly, parastigmatic vessels present. Three~five stigmata in a mesh. The arrangement of stigmata may be slightly irregular in some parts. Tentacles 20-25 including minute ones; branches in 2 orders, branches of the first order are very long and thin. Ciliated groove simple U-shaped or crescent. Dorsal lamina a series of languets.

Alimentary system: Alimentary canal figures a wide loop in the ventral half of the left side. Liver yellowish white in colour. Anus plainly margined. Many minute follicular appendages arranged densely along the inner side of the first intestinal loop.

Gonad: The right gonad consists of ca. 25 genital capsules and the left one consists of ca. 20 capules. Each gonad nearly straight, the duct of the right gonad turns sharply dorsads. Ovary occupies the side of attachment of each capsule.

Remarks: The present description is given as the supplement of the original diagnosis based on a single small individual found in Matoya Bay. This species resembles closely *Cynthia squamulosa* ALDER in the European waters. The latter differs, however, from the former in having lesser longitudinal vessels on the branchial folds, 6-7 instead of 5-14 in *P. lepidoderma*, and contrarily more intermediate vessels, 3-4 instead of 0-2 in *P. lepidoderma*. More crucial comparison is desirable between these two species in the range of variation of the number of inner longitudinal vessels.

14. *Halocynthia igaguri* n. sp.

(Fig. 13)

A globular 12 mm long×11 mm wide individual in the collection, attached to the substratum by the posterior end. Branchial aperture terminal, atrial aperture near the middle of the body. Test thin but tough, yellowish white in colour; the surface is dispersed with minute papillae and armed thoroughly with many short spines, some of which are larger than others and may be 2.5 mm in length. Mantle extremely delicate and adheres firmly to the test.

Branchial sac: Seven folds on each side. Inner longitudinal vessels arranged

as follows:—

Left D. 1 (10) 2 (15) 2 (15) 2 (14) 2 (11) 2 (8) 1 (5) 0 V.

Right D. 1 (9) 1 (15) 2 (14) 2 (13) 2 (12) 2 (10) 1 (5) 1 V.

The seventh (ventral-most) fold is smallest. One to three thinner transverse vessels between each pair of thicker ones. Parastigmatic vessels present in the ventral half of the sac. About five elongate stigmata in a mesh. Tentacles 8, excluding small ones; branches in 2 orders, rarely with minute branches of the third order. Ciliated groove simple U-shaped. Dorsal lamina a series of languets.

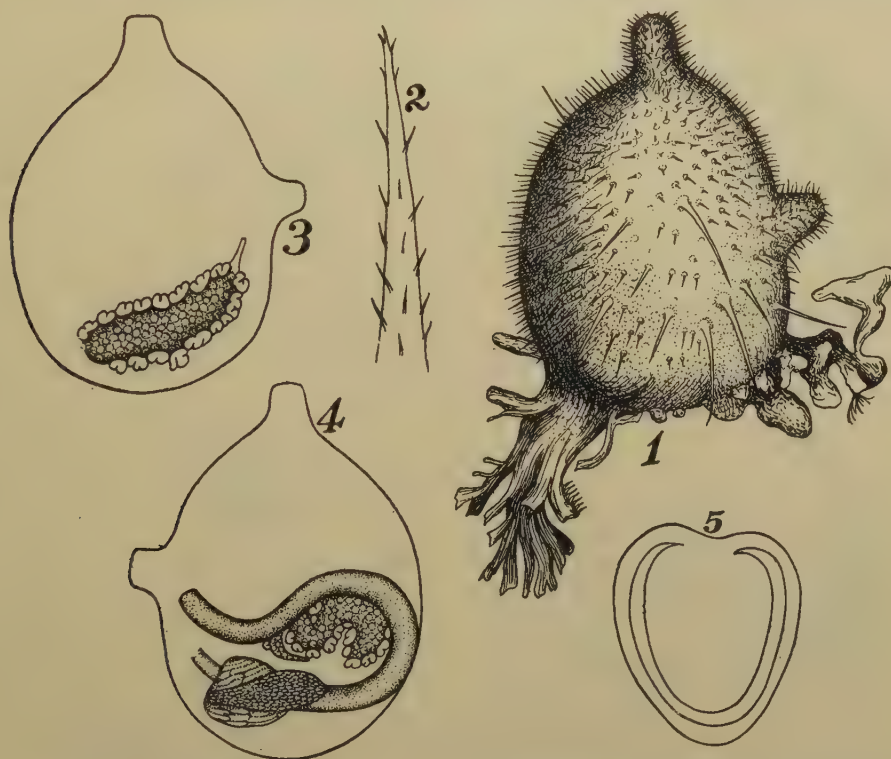


Fig. 13. *Halocynthia igaguri* n.sp. 1—Entire animal from left side, 2—Spine, enlarged; 3—Mantle body, right half from inside; 4—Mantle body, left half from inside; 5—Dorsal tubercle, magnified.

Alimentary system: Alimentary canal forms a simple wide loop in the posterior half on the left side. Liver is whitish and divided into anterior and posterior parts, the former consists of linear plications and the latter consists of follicular lobules. Anus plainly margined.

Gonad: One gonad on the right and two in the intestinal loop on the left side, the dorsal one of which is much smaller than the ventral one. Testicular

lobules marginal.

Remarks: The fewness of branchial folds and gonads is the characteristic of the present new species, besides the smaller size of the animal.

15. *Microcosmus multitentaculatus* n. sp.

(Fig. 14)

A 22 mm long $\times$ 14.5 mm wide individual in the material. The animal is roughly oval in shape and attached to the substratum by the left ventral side.



Fig. 14. *Microcosmus multitentaculatus* n. sp. 1—Entire animal from right side, 2—Mantle body, left half from inside; 3—Mantle body, right half from inside; 4—Dorsal tubercle, magnified.

Branchial aperture terminal. Atrial aperture slightly behind the middle of the body. Both apertures 4-lobed; siphons very short, but distinct.

Test of considerable thickness, leathery and yellowish brown in colour. The surface is roughly smooth except the neighbouring areas of siphons, which is somewhat wrinkled.

Mantle considerably thick, yellowish-white in colour. Longitudinal and transverse muscles arranged regularly.

Branchial sac: Seven folds on each side. Inner longitudinal vessels arranged as follows:

Left	D.	2	(21)	1	(18)	1	(18)	2	(18)	2	(15)	2	(13)	1	(7)	1	V.
Right	D.	1	(19)	1	(20)	1	(18)	1	(18)	2	(16)	1	(16)	1	(12)	0	V.

Three thinner transverse vessels between thicker ones. Parastigmatic vessels present. Five to seven elongate stigmata in a mesh, they may be 10 in meshes along the endostyle. Tentacles ca. 30 including large and small ones, branches in 3 orders. Ciliated groove U-shaped with terminals curled in. Edge of dorsal lamina plain.

Alimentary system: Intestinal loop very narrow. Liver yellowish white. Anus attached to the dorsal edge of the branchial sac, its margin plain.

Gonad: The right gonad consists of one oval mass and the left one consists of two masses, the dorsal one of which is situated dorsal to the dorsal branch of the intestinal loop, while the ventral one is in the loop.

Remarks: It is certain that the present specimen does not represent a young individual of *Microcosmus hartmeyeri* OKA, because the former has more tentacles, ca. 30 instead of 14-30 (usually ca. 15) in the latter, and the U-shaped ciliated groove opened anteriorly instead of C-shaped one opened toward the right in the latter.

16. *Eugyrioides glutinans* (MOELLER), 1842

(Figs. 15-16)

Eugyra (*Eugyrioides*) *asamusi*—TOKIOKA (1949): Publ. Seto Mar. Biol. Lab. Vol. 1, pp. 12-13.

Eugyra sp.—TOKIOKA (1951): Publ. Seto Mar. Biol. Lab., Vol. 1, No. 4, p. 182, Pl. XI fig. 7.

Eugyrioides glutinans—TOKIOKA (1953): Ascidians of Sagami Bay, pp. 291-293, Pl. LXXVII figs. 7-9.

A 19 mm long, nearly globular, individual was dissected for descriptions. Branchial aperture 6-lobed. Test soft cartilaginous, transparent and thicker on the left side than on the right side. The surface is covered with hairy processes which carry mud or fine sand grains. Mantle contains sparsely small spherical bodies, 50-70 μ in diameter and consisting of many delicate crystalline substances arranged radially, which are not calcareous, because they are insoluble in acid. Six inner longitudinal vessels on each side of the branchial sac. The dorsal-most vessel is divided into 3 branches on the left side and into 2 branches on the right. The formation of infundibula is more conspicuous in the ventral half than

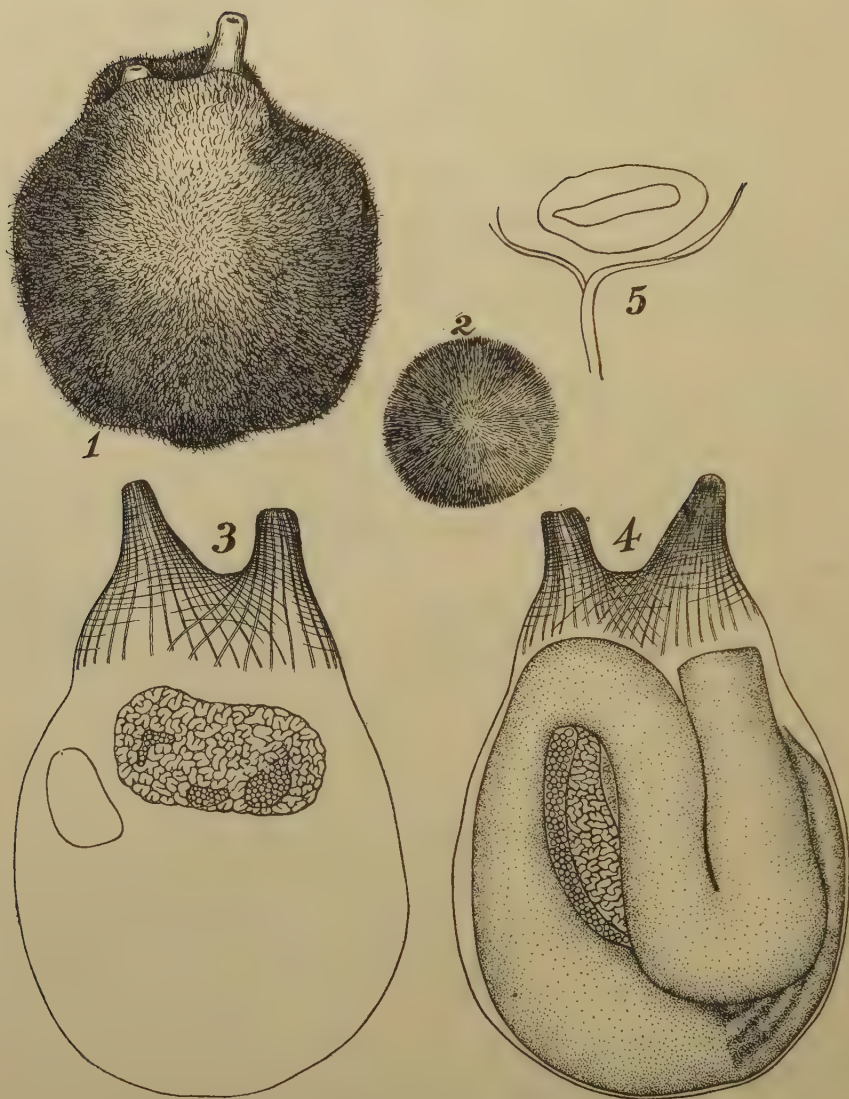


Fig. 15. *Eugyrioides glutinans* (MOELLER). 19 mm long individual.
 1—Entire animal from left side, 2—Spherical body in mantle, $\times 440$; 3—Mantle body from right side, 4—Mantle body from left side, 5—Dorsal tubercle, magnified.

in the dorsal half of the sac. Each infundibulum consists of two stigmata coiling 7-8 times. About 10 large tentacles, branches in 3 orders. Ciliated groove a short transverse slit. The second intestinal loop narrow, its axis passes the pyloric end of the gastric portion. Oesophagus opens to the branchial sac slightly in front of the middle of the body. The right side of the gastric portion

is plicated conspicuously and forms a yellowish hepatic region. Anus plainly margined. The right gonad rather massive, testis occupies the side of attachment and the ovary situated on the free surface.

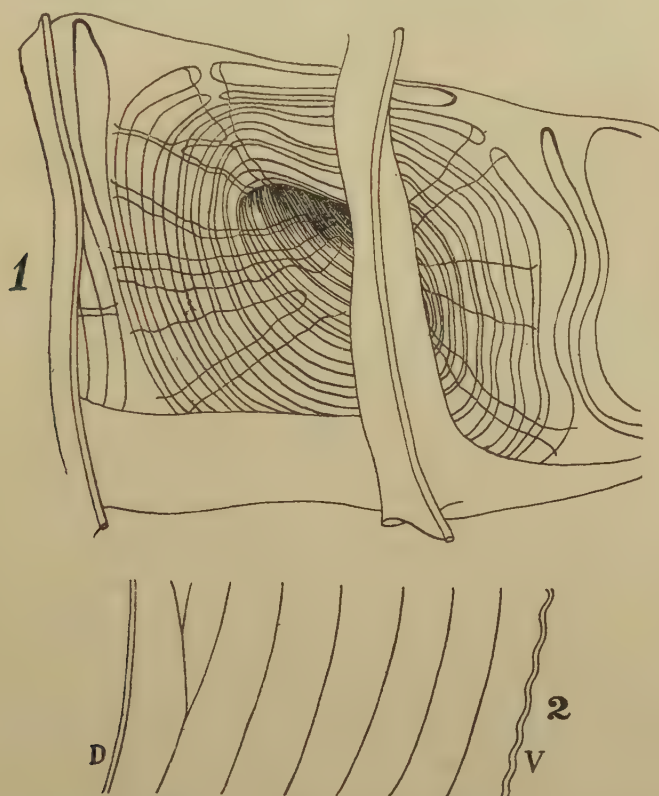


Fig. 16. *Eugyrioides glutinans* (MOELLER). 1—An infundibulum from inside, $\times 33$; 2—Schema of inner longitudinal vessels on the left side.

Remarks: The differences found between the present large specimen and those described previously are considered as individual variations and of no specific importance.



CONTRIBUTIONS TO JAPANESE ASCIDIAN FAUNA. VI
SIMPLE ASCIDIANS OF THE MUSEUM OF HUKUI¹⁾

TAKASI TOKIOKA

Seto Marine Biological Laboratory, Sirahama

With Plate I and 3 Text-figures

A small collection of simple ascidians of the local museum of Hukui, the chief city of Hukui-Prefecture on the Japan Sea side, was offered to me for examination. All these specimens were collected by Mr. SADAHITI HOBAYASHI of Haruyama Primary School of the city. They are:—

- *1 *Cnemidocarpa macrogastra* (OKA)
- 2 *Styela plicata* (LESUEUR)—Loc.: Obama Bay.
- *3 *Styela longipedata* TOKIOKA
- *4 *Pyura lepidoderma* TOKIOKA
- *5 *Herdmania momus* (SAVIGNY)
- 6 *Halocynthia roretzi* (DRASCHE)—Loc.: Turuga Bay.
- 7 *Podocynthia turboja* OKA—Loc.: Obama Bay.
- 8 *Microcosmus multitentaculatus* TOKIOKA—Loc.: Obama Bay.

Four species with an asterisk were found attached to a single shell of *Turcica coreensis* PEASE, dredged in Obama Bay and 38 mm in height. I wish to give some notes on some of these specimens in the following.

Cnemidocarpa macrogastra (OKA), 1935

(Plate I, Fig. 1; Text-fig. 1)

A 25 mm long×17 mm high, oval individual. Apertures are situated on the dorsal side and about 10 mm apart from each other, they are sessile and 4-lobed. Test ca. 0.5 mm in thickness, very tough and whitish in colour. Surface nearly smooth. Many endocarps on the inner side of the mantle. Atrial tentacles numerous.

1) Contributions from the Seto Marine Biological Laboratory, No. 199.

Branchial sac: Inner longitudinal vessels on folds much more numerous than in specimens previously recorded. Intermediate vessels numerous as in specimens reported from Sagami Bay.

Left	D.	1	(31)	7	(27)	6	(26)	6	(18)	5	V.
Right	D.	3	(30)	8	(33)	5	(27)	7	(21)	4	V.

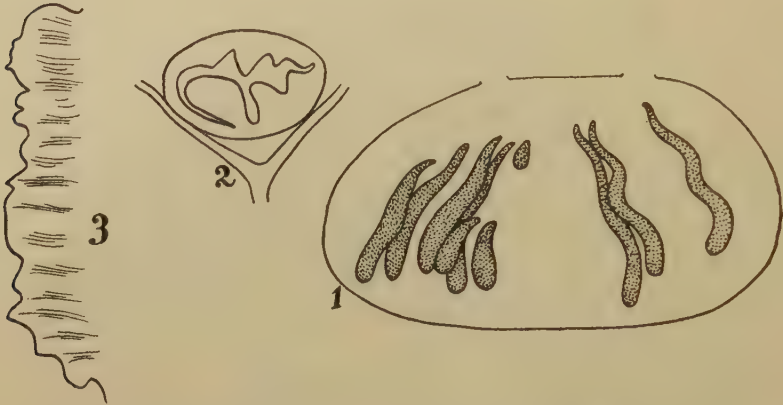


Fig.1. *Cnemidocarpa macrogastra* (OKA). 1—Right half of mantle body from inside, 2—Dorsal tubercle, enlarged; 3—Serrated part of dorsal lamina, $\times 45$.

Three to seven thin transverse vessels between a pair of thicker ones. Parastigmatic vessels present. Three to five stigmata in a mesh. About 25 tentacles including large and small ones. Ciliated groove shows a rather irregular course. Dorsal lamina very broad, partially serrated as shown in Text-fig. 1-3.

Alimentary system: Stomach occupies more than a half of the ventral branch of the intestinal loop. Anus with ca. 10 faint lobes.

Gonad: Ten on the right side and nine on the left.

Styela longipedata TOKIOKA, 1953

A 70 mm long individual, a half of the body length occupied by body proper. Stalk thin. Siphons strongly contracted. Ciliated groove U-shaped.

Pyura lepidoderma TOKIOKA, 1949

(Plate I, Fig. 2)

A 10 mm long $\times$ 10 mm high individual. The test whitish in colour.

Herdmania momus (SAVIGNY), 1816

One specimen, 18 mm×21 mm in size, whitish in colour and rather in bad state of preservation.

Podocynthia turboja OKA, 1929

(Plate I, Fig. 3; Text-fig. 2)

OKA, A. (1929): Ueber eine neue gestielte Monascidie *Podocynthia turboja* n.g. sp., Proc. Imp. Acad., Vol. V, No. 2, pp. 94-96, Figs. A & B.

One specimen in the material. Body globular, 15 mm long×12 mm wide and with apertures on small prominences situated at the anterior side of the body; stalk 38 mm in length, ca. 2 mm in thickness near the anterior end and ca. 1 mm near the posterior end which is ramified and holds gravels between the branches. Small root-like side prominences are issued from the stalk. The animal seems to be laying on the substratum.



Fig. 2. *Podocynthia turboja* OKA. 1—Large spine around atrial aperture, ×75; 2—Small spine, ×75; 3—Spinule, ×200; 4—Right half of mantle body from inside, 5—Left half of mantle body from inside, 6—Dorsal tubercle, enlarged.

Test very thin, but tough. It is whitish on the body proper and pale yellowish on the stalk. The whole surface is covered with minute spines; spines on the stalk are sparsely distributed and slightly longer than those on the body proper. Several large spines found around the atrial aperture. Spines are all armed with spinules.

Spines on the body proper about 280 μ in length.

Spines on the stalk about 350 μ in length

Large spines around the atrial aperture about 1.2 mm in length.

Mantle very thin and translucent. A thin vascular prominence issued from the posterior end of the body and penetrates the stalk. Atrial velum well developed. Many endocarps on the inner side.

Branchial sac: Seven folds on the left side and eight on the right. Arrangement of the inner longitudinal vessels can not be examined in detail, because the branchial sac is considerably mutilated. Probably, about a dozen vessels on each fold and 1-2 vessels in the interspace. Parastigmatic vessels found in many places. Five to six stigmata in a mesh. Tentacles ca. 15 including large and small ones; branches in 2 orders. Ciliated groove U-shaped. Dorsal lamina represented by a series of languets as in *Pyura*, *Herdmania* and *Halocynthia*.

Alimentary system: First intestinal loop nearly circular, second loop wide and distinct. Rectum long, anus plainly margined. Stomach globular, longitudinally plicated except for the dorsal side. Follicular hepatic lobes absent.

Gonad: One massive and orange brown gonad on each side.

Remarks: OKA's original description on the dorsal lamina... "Dorsalfalte: ziemlich breit, dünn, gerippt, mit dünnen, langen, den Rippen entsprechenden Zähnen" ... differs considerably from the description on the present specimen, in which the lamina is represented by a series of languets arranged on the crest. This difference is easily attributable to the difference in the state of contraction. The most incomprehensive difference is that found in the gastric region of the alimentary system. The original description is... "Magen nicht deutlich abgesetzt, mit zahlreichen kleinen Leberanhängen". I consider, however, that the following idea is not impossible that the gastric region has longitudinal plications, besides small follicular hepatic lobes which may be missing in some individuals or easily torn off in the course of dissection. The distinctness of the gastric region may occur as a result of the contraction of the body. If this idea is allowed, differences between the genera *Podocynthia* and *Halocynthia* must be reduced to the single point that *Podocynthia* has the dorsal lamina, somewhat broad and with deeply serrated margin, while *Halocynthia* has a series of languets

in place of a membrane. The existence of the stalk and the fewness of gonads can not be considered to be of generic importance. As to the fewness of gonads, we may cite *Halocynthia igaguri* TOKIOKA as an example. Lastly, it must be further discussed whether the difference in the appearance of the dorsal lamina, mentioned above, is worthy to be treated as a characteristic of the generic importance or not.



Fig. 3. *Microcosmus multitentaculatus* TOKIOKA. 1—Right half of mantle body from inside, 2—Left half of mantle body from inside, 3—Dorsal tubercle, enlarged.

Microcosmus multitentaculatus TOKIOKA, 1953

(Plate I, Fig. 4; Text-fig. 3)

One specimen in the material; 42 mm in length, 32 mm in breadth and 45 mm in height. The animal attached to the substratum by the ventral side which issues many root-like protuberances holding gravels or carrying sand grains and reaches 22 mm in height. Branchial aperture subterminal, atrial aperture slightly behind the middle of the body. Both siphons very short, but stout; apertures 4-lobed. The dorsal side of the body is strongly corrugated. Test yellowish and sprinkled with red patches at several parts. It is ca. 1 mm in thickness, leathery, hard and very tough; inner surface white and glistening. Mantle body ca. 30 mm in height. Mantle of moderate thickness and yellowish brown in colour. Atrial velum well developed. Several endocarps on the inner side.

Branchial sac: Inner longitudinal vessels arranged as follows:

Left	D.	2	(26)	1	(24)	1	(26)	1	(25)	2	(23)	3	(20)	1	(13)	1	V.
Right	D.	1	(27)	1	(26)	1	(26)	1	(26)	2	(24)	2	(22)	2	(18)	0	V.

Transverse vessels arranged as ...thick-thin-thin-thin-medium-thin-thin-thin-thick... Parastigmatic vessels present. Eight to ten small stigmata in a mesh. Tentacles 24, including large and small ones: branches in 3 orders. Ciliated groove U-shaped, with incurled anterior horns.

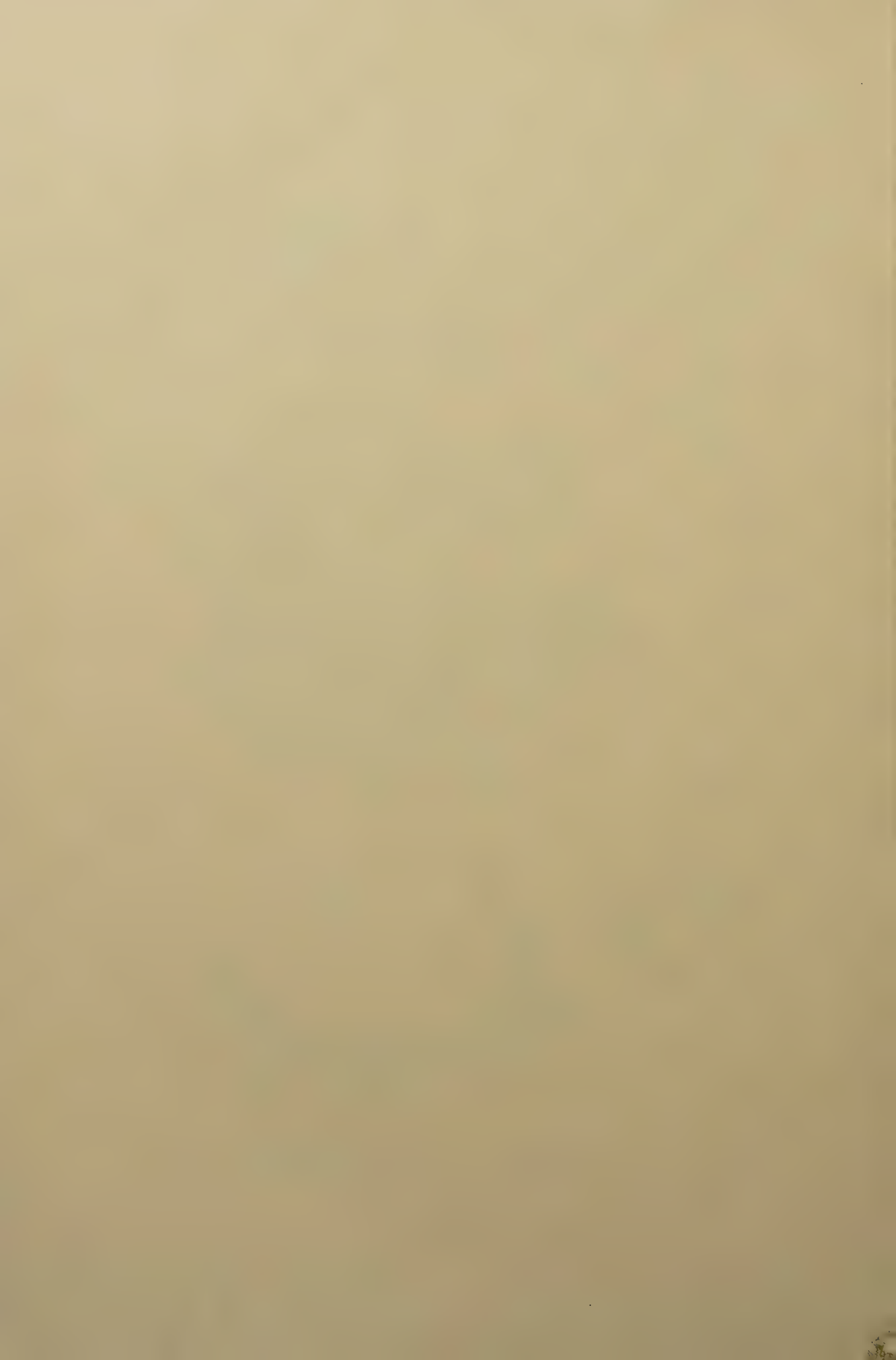
Alimentary system: Anus plainly margined.

Gonad: One gonad on each side. The right gonad is roundish in outline, while the left gonad consists of 7 capsules arranged roughly in two transverse rows on the narrow intestinal loop. Ovary develops merely in the middle capsule of the dorsal row indicated by a distinct gonoduct, other 6 capsules contain only testicular follicles and issue each thin vasa efferentia toward the capsule containing ovary.

EXPLANATION OF PLATE I

1. *Cnemidocarpa macrogastra* (OKA), dorsal side.
2. *Pyura lepidoderma* TOKIOKA, right side.
3. *Podocynthia turboja* OKA, right side.
4. *Microcosmus multitentaculatus* TOKIOKA, right side.





FISSURELLIDAE IN JAPAN (2)*

TADASHIGE HABE

Zoological Institute and Seto Marine Biological Laboratory,
Kyoto University

With Plate II

This is the second of a series of papers dealing with the Fissurellid fauna of Japan. Part I (HABE, *Illust. Cat. Jap. Shells*, **17**, pp. 109-120, 1951) contained the genera *Macroschisma*, *Scutus*, *Zeidora*, *Rimula*, *Fissurisepta* and *Puncturella*. The part given here reports on the species of the genera *Emarginula*, *Laeviemarginula*, *Emarginella*, *Tugali*, *Tugalina*, *Montfortula* and *Montfortia*.

Genus *Emarginula* LAMARCK 1801

1801 *Emarginula* LAMARCK, *Syst. Anim. s. Vert.*, p. 69.

1810 *Emarginulus* MONTFORT, *Conchyl. Syst.*, p. 74.

Type species: *Emarginula conica* LAMARCK (monotypy).

Emarginula fujitai n. sp.

(Pl. II, Figs. 32, 33)

1929 *Emarginula foveolata* FUJITA, *Venus*, **1** (3), p. 88, pl. 3, fig. 10 and textfig. 1, non SCHEPMAN 1908.

1929 *Emarginula foveolata* KURODA, *l.c.*, p. 93.

Shell rather large, attaining up to 25 mm. in length, deeply sculptured, white, highly conical, the height being about four-fifths of the shell length; anterior slope convex and posterior slope concave, immediately below the apex, then extending downward in a straight line to the margin; apical whorl small, smooth and polished, close to a little below the summit, bent down posteriorly and situated at the posterior third of the length of the shell; anal fasciole narrow,

* Contributions from the Seto Marine Biological Laboratory, No. 200.

with numerous arched lamellae; fissure rather short and about one-sixth the length of the anterior slope; sculpture consists of about 30 strong primary ribs, radiating from the apex to the margin and secondary ribs alternating with them; numerous concentric cords dividing the spaces between the ribs into deeply excavated coarse square pits, thus giving the surface a foveolate appearance; interior of the shell chalky white; margin crenulated by the terminations of the ribs.

Height 14.8 mm., length of aperture 21.5 mm., breadth of aperture 16.0 mm. (figured type specimen deposited in the Geological Institute of Kyoto University).

Height 18.2 mm., length of aperture 25.6 mm., breadth of aperture 18.7 mm. (examined specimen collected from Wakayama Pref., Honshu by Mr. Akibumi TERAMACHI).

Type locality: Tateyama Bay, Bōsō Peninsula, Honshu.

Distribution: Tateyama Bay and off Wakayama Pref., Honshu and Tosa Bay, Shikoku.

Fossil occurrence: Moeshima in the Kagoshima Bay, Kyushu (Pleistocene).

Remarks: This species was erroneously recorded as *E. foveolata* SCHEPMAN from Tateyama Bay by Mr. Tadashi FUJITA, to whom the specific name is dedicated. In the former the shell is more highly conical and the aperture elliptical in shape, not distinctly narrowed anteriorly.

Emarginula hataii n. sp.

(Pl. II, Figs. 13, 20)

1940 *Emarginula foveolata* NOMURA et HATAI, Saito Ho-on Kai Mus. Res. Bull. 19, p. 59, non SCHEPMAN 1908.

Shell medium in size, reaching 13 mm. in length, solid, milky white, the height being about 60% of the shell length; aperture elongate elliptical in shape; anterior slope strongly, convexly arched and posterior slope concave immediately below the apex, more weakly concave downward; apical whorls one and one half in number, and placed strongly down the shell and situated at the posterior end; anal fasciole narrow, distantly crossed by transverse lamellae; fissure long and narrow, slightly shorter than one half of the anterior slope; radial sculpture consists of 21 to 27 widely spaced primary ribs, and in addition to them, there occur secondary ribs between each two of them; concentric sculpture consists of widely spaced cords forming small nodules, where they intersect the ribs; these cords divide the spaces between the ribs into coarse and deep square pits; two radial ribs, a little more highly elevated than the rest, border the fasciole

and the fissure; margin crenulated by the terminations of ribs; interior of shell chalky white.

Height 8.0 mm., length of aperture 12.8 mm., breadth of aperture 9.0 mm. (figured type specimen).

Height 8.2 mm., length of aperture 12.8 mm., breadth of aperture 8.5 mm. (paratype specimen).

Height 6.3 mm., length of aperture 11.4 mm., breadth of aperture 8.3 mm. (examined specimen from off Tugaru Beninsula, Aomori Pref., Honshu; Sôyômaru station No. 646, 123 m. in depth).

Height 6.8 mm., length of aperture 12.4 mm., breadth 8.6 mm. examined specimen from off Noto Peninsula, Honshu, about 100 fathoms in depth).

Height 6.6 mm., length of aperture 12.6 mm., breadth of aperture 8.6 mm. (examined specimen from off Noto Peninsula, Honshu).

Type locality: Kyuroku-jima, Aomori Pref., Honshu (210 m. and 150 m. in depth).

Distribution: Japan Sea (off Noto Peninsula to off Tugaru Peninsula).

Remarks: This new species was reported as *E. foveolata* SCHEPMAN from Kyuroku-jima, Aomori Pref., Honshu by Sitihei NOMURA and Katora HATAI, but both species are quite different in shape. *E. fujitai*, also reported as *E. foveolata* by Tadashi FUJITA from Tateyama Bay, Honshu, differs from this new species in the larger and higher conical shell with the pointed apex and the short fissure. I take pleasure in naming this for Dr. Katora HATAI.

Emarginula fragilis YOKOYAMA

(Pl. II, Figs. 21, 22)

1920 *Emarginula fragilis* YOKOYAMA, Jour. Coll. Sci. Imp. Univ. Tokyo, **39** (6), p. 98, pl. 6, fig. 10.

1929 *Emarginula fragilis* FUJITA, Venus, **1** (3), p. 88, pl. 3, fig. 9 and textfig. 2.

1929 *Emarginula fragilis* KURODA, l.c., **1** (3), p. 94.

Height 10.5 mm., length of aperture 16 mm., breadth of aperture 11.5 mm. (figured specimen collected from off Wakayama Pref., Honshu).

Height 10.1 mm., length of aperture 17.7 mm., breadth of aperture 12.0 mm. (examined specimen collected by Mr. Akibumi TERAMACHI from off Wakayama Pref., Honshu).

Height 10.6 mm., length of aperture 16.7 mm., breadth of aperture 11.4 mm. (examined specimen collected from Sagami Bay, Honshu by Mr. Ryosuke KAWAMURA).

Height 7.8 mm., length of aperture 13.8 mm., breadth of aperture 9.8 mm.

(examined specimen collected from Sagami Bay).

Type locality: Harashita, Shimo-miyata, Kanagawa Pref., Honshu.

Distribution: Sagami Bay and off Wakayama Pref., Honshu and Tosa Bay, Shikoku.

Fossil occurrence: Type locality (Pleistocene).

Emarginula regia n. sp.

(Pl. II, Figs. 30, 31)

Shell large, exceeding 33 mm. in length and 20 mm. in height, conical, its height being two-thirds of the shell length, colour ashy grey, probably due to the long stay in the mud; aperture broadly ovate; anterior slope straight or feebly convex, posterior slope somewhat concave below the apex, extending downward in a straight line to the margin; apical whorls small, smooth, coiled down a little below the summit and situated at about the posterior third of the shell length; anal fasciole narrow, formed by very closely set transverse lamellae; fissure also narrow, one-fourth of the length of the anterior slope; sculpture compact, consists of numerous closely set radial ribs; at the apical area there are about 40 primary ribs, but below numerous finer ribs are intercalated between them, thus the total number of ribs attaining more than 100; also numerous concentric lamellae intersect the radiating ribs, giving scaly aspects on the point of intersection of ribs; margin crenulated by the terminations of the ribs.

Height 19.3 mm., length of aperture 32.9 mm., breadth of aperture 27.0 mm. (figured type specimen collected by Mr. Akibumi TERAMACHI).

Height 21.2 mm., length of aperture 36.3 mm., breadth of aperture 29.5 mm. (paratype specimen).

Type locality: Tosa Bay, Shikoku (about 100 fathoms in depth).

Remarks: *Emarginula hawaiiensis* DALL is the nearest ally of this new species in the general appearances, but may be easily distinguished from this in having the apex situated more posteriorly.

Emarginula crassicosata SOWERBY

- 1863 *Emarginula crassicosata* SOWERBY, Thes. Conch., 3, p. 214, pl. 246, figs. 41, 42.
- 1873 *Emarginula crassicosata* SOWERBY, Conch. Icon., 19, *Emarginula*, pl. 6, fig. 38.
- 1890 *Emarginula crassicosata* PILSBRY, Man. Conch., 12, p. 259, pl. 29, figs. 30-32.
- 1913 *Emarginula crassicosata* THIELE, Conch. Cab., 2 (4a), p. 68, pl. 8, fig. 10.
- 1935 *Emarginula crassicosata* OTUKA, Bull. Earthq. Res. Inst., 13 (4), p. 846, pl. 53, figs. 21a, b.

1951 *Emarginula crassicostata* Is. TAKI, HIRASE's Handb. Illust. Shells, pl. 63, fig. 1.

Height 5.2 mm., length of aperture 10.6 mm., breadth of aperture 7.7 mm. (examined specimen collected by Mr. Akibumi TERAMACHI from Noto Peninsula, Honshu).

Height 5.7 mm., length of aperture 11.5 mm., breadth of aperture 8.1 mm. (examined specimen collected by Mr. Masatoyo OKAMOTO from Kanezaki, Munakata-gun, Fukuoka Pref., Kyushu).

Type locality: unknown.

Distribution: Kyushu; Shikoku and Honshu.

Fossil occurrence: The Oti Graben in Southern Noto Peninsula, Honshu (Pleistocene).

Remarks: This is the commonest species in our coast.

Emarginula hosoyai n. sp.

Shell medium in size, about 11 mm. in length, solid, pale cream yellow in colour, height being about 60% of the length: aperture elliptical; anterior slope convex; posterior slope slightly concave or straight; apical whorls one and one half in number and are reduced to a small hook; the position of apical whorls close to a little below the summit and situated at the posterior end; anal fasciole narrow, provided with transverse lamellae; fissure narrow, its length being one-fifth of the anterior slope; sculpture consists of about 40 radiating ribs from the apex; below secondary ribs appear between each two of the primary ribs; numerous concentric cords divide the spaces between ribs into small square pits.

Height 8.2 mm., length of aperture 13.6 mm., breadth of aperture 10.1 mm. (type specimen collected by Mr. Akibumi TERAMACHI).

Height 4.5 mm., length of aperture 8.6 mm., breadth of aperture 6.0 mm. (paratype).

Height 4.8 mm., length of aperture 8.9 mm., breadth of aperture 6.5 mm. (examined specimen collected by Mr. Kakujiro HOSOYA from the Sagami Bay, 50 fathoms in depth).

Height 5.1 mm., length of aperture 8.9 mm., breadth of aperture 6.6 mm. (examined specimen from the Sagami Bay).

Type locality: Tosa Bay, Shikoku (about 70 fathoms in depth).

Distribution: Sagami Bay and off Wakayama Pref., Honshu and Tosa Bay, Shikoku.

Remarks: This new species differs quite sharply from *E. hataii* to which it

appears to be nearest in relationship; the former has more densely set square pits on the cream yellow shell. This species is named in honour of Mr. Kakujiro HOSOYA, who is a famous collector of shells of Sagami Bay.

Emarginula teramachii n. sp.

(Pl. II, Figs. 14, 23)

Shell medium in size, reaching about 10 mm. in length; dull white, probably due to its existence in the mud, highly conical; the height being about 70% of the shell length; anterior slope gently convex and posterior slope concave immediately below the apex, then extending downward in a straight line to the margin; aperture elliptical in sharpe; apical whorls small, smooth and polished, hooked down posteriorly and situated at the posterior end; anal fasciole long and narrow; fissure narrow, shorter than one-third of the length of the anterior slope; sculpture consists of about 15 primary radial cords and at a short distance from the apex, secondary ribs appear between each two of the primary ribs; forming nodules on the point of intersection, dividing the spaces between ribs into deeply excavated square pits, giving the shell a lattice-like appearance; margin crenulated by the terminations of the ribs.

Height 6.7 mm., length of aperture 9.5 mm., breadth of aperture 7.0 mm. (the largest paratype specimen collected by Mr. Akibumi TERAMACHI).

Height 6.2 mm., length of aperture 8.6 mm., breadth of aperture 6.2 mm. (figured type specimen).

Height 5.6 mm., length of aperture 7.5 mm., breadth of aperture 5.5 mm. (paratype specimen).

Type locality: Tosa Bay, Shikoku (about 70 fathoms).

Remarks: *Emarginula adamsiana* SOWERBY somewhat relates to this new species in its shape, but has the sculpture on the shell decidedly coarser than in the latter. *Emarginula choristes* DALL from off Gwajajima, south of Kyushu, is another allied one, but it has a larger shell with the sculpture differing from that of this new species. The specific name is dedicated to Mr. Akibumi TERAMACHI who is an expert of the shell collecting in Japan.

Emarginula choristes DALL

1925 *Emarginula choristes* DALL, Proc. U. S. Nat. Mus., 66 (17), p. 16, pl. 26, figs. 1, 4.

Height 18 mm., length of aperture 17 mm., breadth of aperture 12 mm.

Type locality: Gwajajima, south of Kyushu (361 fathoms in depth).

Emarginula adamsiana SOWERBY

1863 *Emarginula adamsiana* SOWERBY, Thes. Conch., 3, p. 214, pl. 246, figs. 27, 28.

1873 *Emarginula adamsiana* SOWERBY. Conch. Icon., 19, *Emarginula*, pl. 4, fig. 29.

1890 *Emarginula adamsiana* PILSBRY. Man. Conch., 12, p. 260, pl. 28, fig. 32.

1913 *Emarginula adamsiana* THIELE, Conch. Cab., 2 (4a), p. 63, pl. 7, fig. 13.

Height 3.0 mm., length of aperture 6.0 mm., breadth of aperture 4.25 mm. (after THIELE).

Type locality: Japan.

Emarginula tosaensis n. sp.

Shell rather large for the genus, attaining 18 mm. in length, rather solid, pale yellow in colour, sometimes ornamented with broad radial patterns, the height being about 50% of the length of shell; aperture elliptical in shape; anterior slope long, gently convex and the posterior slope short, straight except for the part below the apex which is concave; apical whorls small and smooth, coiled down the summit and situated near the posterior end; anal fasciole long and narrow; the fissure also narrow, but rather short, about one-fourth of the anterior slope; sculpture rather compact, consisting of about 30 radial ribs, below secondary ribs appear between each two of the primary ribs; numerous concentric cords which are a little lamellae on the point of intersection resulting numerous small square pits; margin denticulate; interior of the shell white and polished.

Height 8.7 mm., length of aperture 18.0 mm., breadth of aperture 12.8 mm. (type specimen collected by Mr. Akibumi TERAMACHI).

Height 8.0 mm., length of aperture 14.7 mm., breadth of aperture 10.8 mm. (paratype specimen).

Height 6.5 mm., length of aperture 14.5 mm., breadth of aperture 9.9 mm. (paratype specimen).

Height 8.1 mm., length of aperture 16.7 mm., breadth of aperture 11.9 mm. (paratype specimen).

Height 6.7 mm., length of aperture 13.6 mm., breadth of aperture 9.5 mm. (examined specimen collected from Moeshima in the Kagoshima Bay, Kyushu).

Type locality: Tosa Bay, Shikoku (about 70 fathoms).

Fossil occurrence: Moeshima in the Kagoshima Bay, Kyushu (Pleistocene).

Remarks: this new species resembles *Emarginula hosoyai*, but may be distinguished from the latter in having the larger and lower conical shell with

the radial colour markings. *Emarginula maculata* SOWERBY is somewhat close to the young specimen of this species.

Emarginula maculata A. ADAMS

- 1863 *Emarginula maculata* A. ADAMS, Thes. Conch., 3, p. 215, pl. 246, figs. 31, 32.
 1873 *Emarginula maculata* SOWERBY, Conch. Icon., 19, *Emarginula*, pl. 5, fig. 32.
 1890 *Emarginula maculata* PILSBRY, Man. Conch., 12, p. 263, pl. 28, fig. 4.
 1915 *Emarginula maculata* THIELE, Conch. Cab., 2 (4a), p. 95, pl. 11, figs. 18, 19.

Height 3.4 mm., length of aperture 7.5 mm., breadth of aperture 5.6 mm.
 (after SOWERBY's figures).

Type locality: Goto Islands, Japan.

Emarginula japonica SOWERBY

- 1863 *Emarginula japonica* SOWERBY, Thes. Conch., 3, p. 216, pl. 246, figs. 43, 44.
 1873 *Emarginula japonica* SOWERBY, Conch. Icon., 19, *Emarginula*, pl. 8, fig. 59.
 1890 *Emarginula japonica* PILSBRY, Man. Conch., 12, p. 264, pl. 28, fig. 18.
 1915 *Emarginula japonica* THIELE, Conch. Cab., 2 (4a), p. 94, pl. 11, figs. 14, 15.

Height 5.2 mm., length of aperture 10.2 mm., breadth of aperture 7.0 mm.
 (after A. ADAMS' figures).

Type locality: Japan.

Remarks: This is a small purplish shell and has never been rediscovered since.

Emarginula concinna A. ADAMS

(Pl. II, Figs. 10, 15)

- 1852 *Emarginula concinna* A. ADAMS, Proc. Zool. Soc. London, 19, p. 85.
 1863 *Emarginula concinna* A. ADAMS, Thes. Conch., 3, p. 212, pl. 246, figs. 34, 39, 40.
 1873 *Emarginula concinna* SOWERBY, Conch. Icon., 19, *Emarginula*, pl. 2, fig. 13.
 1890 *Emarginula concinna* PILSBRY, Man. Conch., 12, p. 257, pl. 28, figs. 5, 6.
 1909 *Emarginula concinna* CONTURIER, Jour. de Conchyl., 55, p. 172.
 1913 *Emarginula concinna* THIELE, Conch. Cab., 2 (4a), p. 61, pl. 7, fig. 10.

Height 2.6 mm., length of aperture 7.3 mm., breadth of aperture 4.7 mm.
 (figured specimen collected by Mr. Akibumi TERAMACHI from Ryukyu group).

Height 2.4 mm., length of aperture 6.7 mm., breadth of aperture 4.1 mm.
 (examined specimen from Ryukyu group).

Type locality: Unknown.

Distribution: Ryukyu group and Honshu.

Emarginula compta n. sp.

(Pl. II, Figs. 11, 12)

Shell small, reaching 7 mm. in length of shell, height being about 60 to 65% of the length; ashy white, maculated with four square blackish patches, one in front of the apex and one below the summit, the other two on both side slopes, but sometimes lacking partly or all of them; apical whorl smooth and polished, bent a little below the summit and reduced to a small hook, situated at the posterior end; anterior slope strongly convex and posterior slope straight; anal fasciole narrow and with numerous arched transverse lamellae; fissure also narrow and rather short, one-fifth of the length of the anterior slope; sculpture consists of about 30 primary ribs radiating from the apex to the margin, secondary ribs alternate with them; the distantly placed concentric cords cross the surface of the shell, forming nodules where they intersect the ribs dividing the spaces between the ribs into square pits; in addition to them numerous densely set concentric threads cover all over the surface of the shell, forming the delicate texture; margin crenulated.

Height 4.3 mm., length of aperture 7.1 mm., breadth of aperture. 4.8 mm. (the largest paratype specimen collected by Mr. Akibumi TERAMACHI from Ryukyu group).

Height 2.8 mm., length of aperture 4.8 mm., breadth of aperture 3.3 mm. (figured type specimen).

Height 3.5 mm., length of aperture 6.1 mm., breadth of aperture 4.4 mm. (paratype specimen).

Type locality: Okinawa, Ryukyu group.

Remarks: This new species is very peculiar in the coloration of the shell and differs distinctly from any other species.

Emarginula scabriuscula A. ADAMS

- 1852 *Emarginula scabriuscula* A. ADAMS. Proc. Zool. Soc. London, 19, p. 83.
 1863 *Emarginula scabriuscula* A. A. DAMS, Thes. Conch., 3, p. 213, pl. 246. fig. 36.
 1873 *Emarginula scabriuscula* SOWERBY, Conch. Icon., 19, *Emarginula*, pl. 5, fig. 30.
 1890 *Emarginula scabriuscula* PILSBRY, Man. Conch., 12, p. 268, pl. 28, fig. 31.
 1915 *Emarginula scabriuscula* THIELE, Conch. Cab., 2 (4a), p. 82, pl. 10, figs. 3, 4.

Height 3.1 mm., length of aperture 7.3 mm., breadth of aperture 5.0 mm. (after A. ADAMS' figures).

Type locality: Unknown.

Remarks: This species was reported as occurring in Japan by A. ADAMS, but has never been rediscovered from our seas.

Emarginula imaizumi DALL

1926 *Emarginula imaizumi* DALL, Proc. Biol. Soc. Washington, **39**, p. 65.

1926 *Emarginula* (*imaizumi* var ?) *imella* DALL, Proc. Biol. Soc. Washington, **39**, p. 65.

Height 4 mm., length of aperture 13 mm., breadth of aperture 8.6 mm.

Type locality: Imaizumi, Kagoshima Bay, Kyushu.

Emarginula punctata A. ADAMS

1852 *Emarginula punctata* A. ADAMS, Proc. Zool. Soc. London, **19**, p. 84.

1863 *Emarginula punctata* A. ADAMS Thes. Conch., **3**, p. 215, pl. 246, figs. 29, 30.

1873 *Emarginula punctata* SOWEBY, Conch. Icon., **19**, *Emarginula*, pl. 5, fig. 31.

1890 *Emarginula punctata* PILSBRY, Man. Conch., **12**, p. 263, pl. 28, fig. 33.

1915 *Emarginula punctata* THIELE, Conch. Cab., **2** (4a), p. 93, pl. 11, figs. 11, 12, 13.

Height 3.7 mm., length of aperture 6.3 mm., breadth of aperture 5.0 mm.
(examined specimen collected from Shirahama, Wakayama Pref., Honshu).

Height 3.5 mm., length of aperture 5.8 mm., breadth of aperture 4.7 mm.
(examined specimen collected by Mr. Akibumi TERAMACHI from the Ryukyu group).

Type locality: San Nicholas, Island of Zebu, Philippines (under stones in the lower water).

Distribution: Philippines; Formosa; Ryukyu and Amami groups: Kyushu; Shikoku and Honshu.

Emarginula altilis GOULD

1859 *Emarginula* (*Clypidina*) *altilis* GOULD, Proc. Boston Soc. Nat. Hist., **7**, p. 162.

Height 4 mm., length of aperture 5 mm., breadth of aperture 4 mm.

Type locality: Kagoshima Bay (10 fathoms in depth).

Remarks: This species somewhat resembles *Emarginula punctata* A. ADAMS.

Emarginula variegata A. ADAMS

1852 *Emarginula variegata* A. ADAMS, Proc. Zool. Soc. London, **19**, p. 84.

1863 *Emarginula variegata* A. ADAMS Thes. Conch., **3**, p. 215, pl. 245, figs. 9, 10.

1873 *Emarginula variegata* SOWERBY, Conch. Icon., **19**, *Emarginula*, pl. 4, fig. 22.

1890 *Emarginula variegata* PILSBRY, Man. Conch., **12**, p. 263, pl. 28, fig. 12.

1915 *Emarginula variegata* THIELE, Conch. Cab., **2** (4a), p. 92, pl. 11, figs. 5, 6.

1941 *Emarginula fuliginea* KURODA, Mem. Fac. Sci. Agr. Taihoku Imp. Univ., **22** (4), p. 72, pl. 13 figs. 1, 2,

Height 4.9 mm., length of aperture 10.0 mm., breadth of aperture 7.6 mm.

(examined specimen collected from Tanegashima, south of Kyushu).

Height 4.8 mm., length of aperture 9.8 mm., breadth of aperture 7.3 mm.
(examined specimen from Tanegashima).

Type locality: Philippines.

Distribution: East Indies; Philippines; Formosa; Ryukyu and Amami groups and Kyushu.

Emarginula pileata GOULD

1859 *Emarginula pileata* GOULD, Proc. Boston Soc. Nat. Hist., 7, p. 162.

Height 4 mm., length of aperture 5 mm., breadth of aperture 4 mm.

Type locality: Loo Choo (=Ryukyu).

Genus *Laeviemarginula* HABE 1953

1953 *Laeviemarginula* HABE, Illust. Cat. Jap. Shells, 23, p. 183.

Type species: *Laeviemarginula membranacea* HABE (monotypy).

Laeviemarginula membranacea HABE

(Pl. II, Figs. 16, 17)

1953 *Laeviemarginula membranacea* HABE, Illust. Cat. Jap. Shells, 23, p. 183.

Height 4.7 mm., length of aperture 19.8 mm., breadth of aperture 13.6 mm.
(figured type specimen).

Type locality: Okinawa, Ryukyu group.

Genus *Emarginella* PILSBRY 1890

1890 *Emarginella* PILSBRY, Man. Conch., 12, p. 269.

Type species: *Emarginula cuvieri* AUDOUIN (monotypy).

Emarginella incisula (A. ADAMS)

1952 *Emarginula incisula* A. ADAMS, Proc. Zool. Soc. London, 19, p. 84,

1863 *Emarginula incisula* A. ADAMS, Thes. Conch., 3, p. 211, pl. 245, fig. 2.

1873 *Emarginula incisula* SOWERBY, Conch. Icon., 19, *Emarginula*, pl. 3, fig. 18.

1890 *Emarginula incisula* PILSBRY, Man. Conch., 12, p. 265, pl. 28, fig. 1.

1905 *Emarginula incisula* HEDLEY, Proc. Linn. Soc. N. S. Wales, 30, p. 521.

1915 *Emarginula (Emarginella) incisula* THIELE, Conch. Cab., 2 (4a), p. 98, pl. 11, fig. 26.

Height 4.6 mm., length of aperture 15.8 mm., breadth of aperture 9.0 mm.
(examined specimen collected by Dr. Tokubei KURODA from Amami O-Shima).

Type locality : Unknown.

Distribution : East Indies ; Amami group.

Emarginella planulata (A. ADAMS)

(Pl. II, Figs. 24, 26)

1852 *Emarginula planulata* A. ADAMS, Proc. Zool. Soc. London, 19, p. 86.

1863 *Emargiuula planulata* A. ADAMS, Thes. Conch., 3, p. 211, pl. 245, fig. 1.

1873 *Emarginula planulata* SOWERBY, Conch. Icon., 19, *Emarginula*, pl. 3, fig. 20.

1890 *Emarginula planulata* PILSBRY, Man. Conch., 12, p. 264, pl. 28, fig. 15.

1915 *Emarginula* (*Emarginella*) *planulata* THIELE, Conch. Cab., 2 (4a), p. 28, pl. 11, fig. 27.

Height 9.7 mm., length of aperture 25.3 mm., breadth of aperture 17.0 mm. (figured specimen collected from Wakayama Pref., Honshu by Mr. Akibumi TERAMACHI).

Height 9.5 mm., length of aperture 30.1 mm., breadth of aperture 20.2 mm. (examined specimen collected from Hirado, Nagasaki Pref., Kyushu by Dr. Tokubei KURODA).

Type locality : Singapore (coarse sand and shells, 7 fathoms in depth).

Distribution : Singapore ; Philippines ; Kyushu and Honshu.

Emarginella eximia (A. ADAMS)

(Pl. II, Figs. 3, 4)

1852 *Emarginula eximia* A. ADAMS, Proc. Zool. Soc. London, 19, p. 86.

1863 *Emarginula eximia* A. ADAMS, Thes. Conch., 3, p. 212, pl. 246, fig. 63.

1890 *Emarginula eximia* PILSBRY, Man. Conch., 12, p. 267, pl. 28, fig. 26.

1915 *Emarginula eximia* THIELE, Conch. Cab., 2 (4a), p. 89, pl. 10, figs. 22, 23.

Height 3.3 mm., length of aperture 10.5 mm., breadth of aperture 7.3 mm. (figured specimen collected from the Ryukyu group by Mr. Akibumi TERAMACHI).

Height 3.1 mm., length of aperture 10.7 mm., breadth of aperture 7.1 mm. (examined specimen collected from the Ryukyu group).

Type locality : San Nicholas, Island of Zebu, Philippines (under stones in the lower water).

Distribution : Philippines and Ryukyu group.

Emarginella okinawaensis n. sp.

(Pl. II, Figs. 5, 6)

Shell white, depressed, not attaining 13 mm. in length, the height being about

35~45% in the length of shell; apical whorls are turned backwards and downward and is not hooked; that place about at the middle of shell; anterior slope slightly concave and posterior slope straight or a little convex; anal fasciole narrow and raised; fissure very short, about one-sixth the length of the anterior slope; the primary radial ribs are strong, about nine in number; the secondary ribs intercalated between them; concentric cords are very strong and place distantly on the shell where they give the large excavated square mesh; the crenulations of the margin caused by the primary ribs being particularly large.

Height 4.5 mm., length of aperture 12.9 mm., breadth of aperture 10.1 mm. (figured type specimen).

Height 4.5 mm., length of aperture 11.7 mm., breadth of aperture 9.6 mm. (paratype specimen).

Height 5.2 mm., length of aperture 11.8 mm., breadth of aperture 9.0 mm. (paratype specimen).

Height 3.9 mm., length of aperture 10.9 mm., breadth of aperture 8.6 mm. (paratype specimen).

Type locality: Okinawa, Ryukyu group.

Remarks: This new species approaches to *Emarginella sculptilis* A. ADAMS from the Philippines in the general appearance, but has no colour spots between each of the large ribs on the surface of the shell. *Emarginella crassilabrum* A. ADAMS is another allied one.

Tugali GRAY 1843

1843 *Tugali* GRAY. Dieffenbach Travel in New Zealand, 2, p. 240.

1857 *Tugalia* GRAY, Guide Moll. Brit. Mus., p. 163.

Type species: *Tugali elegans* GRAY (monotypy).

Tugali decussata A. ADAMS

(Pl. II, Figs. 25, 29)

1852 *Tugali decussata* A. ADAMS, Proc. Zool. Soc. London, 19, p. 89.

1863 *Tugalia decussata* A. ADAMS, Thes. Conch., 3, p. 222, pl. 249, fig. 12.

1870 *Tugalia decussata* REEVE, Conch. Icon., 17, *Tugalia*, sp. 6.

1890 *Subemarginula decussata* PILSBRY, Man. Conch., 12, p. 286, pl. 43, figs. 88.

1915 *Emarginula (Tugalia) decussata* THIELE, Conch. Cab., 2 (4a), p. 103, pl. 12, fig. 13.

1915 *Emarginula angustata* THIELE, l.c., p. 108, pl. 15, figs. 27, 28.

1951 *Tugali decussata* ls. TAKI, HIRASE's Handb. Illust. Shells, pl. 63, fig. 5.

Height 5.0 mm., length of aperture 13.3 mm., breadth of aperture 9.3 mm. (examined specimen collected from Shirahama, Wakayama Pref., Honshu).

Height 4.6 mm., length of aperture 14.3 mm., breadth of aperture 9.9 mm.
(figured specimen collected from the same).

Type locality: Philippine islands.

Distribution: Philippines; Kyushu; Shikoku and Honshu.

Tugali scutellaris A. ADAMS

(Pl. II, Fig. 1)

- 1852 *Tugali scutellaris* A. ADAMS, Proc. Zool. Soc. London, **19**, p. 89.
 1863 *Tugalia scutellaris* A. ADAMS, Thes. Conch., **3**, p. 222, pl. 14, figs. 8, 9.
 1870 *Tugalia scutellaris* REEVE, Conch. Icon., **17**, *Tugalia*, fig. 1.
 1890 *Submarginula (Tugalia) scutellaris* PILSBRY, Man. Conch., **12**, p. 286, pl. 43, figs. 81, 82.
 1915 *Emarginula (Tugalia) scutellaris* THIELE, Conch. Cab., **2** (4a), p. 104, pl. 12, fig. 14.

Height 3.3 mm., length of aperture 14.8 mm., breadth of aperture 10.5 mm.
(figured specimen collected by Mr. A. TERAMACHI from Wakayama Pref., Honshu).

Type locality: Bais, Philippines.

Distribution: Philippines and Wakayama Pref., Honshu.

Tugali vadososinuata (YOKOYAMA)

(Pl. II, Figs. 35, 36)

- 1922 *Emarginula vadososinuata* YOKOYAMA, Jour. Coll. Sci. Imp. Univ. Tokyo, **44** (1), p. 117, pl. 6, fig. 5.
 1939 *Tugalia vadososinuata* TIBA, Venus, **9**, p. 44 with textfig.

Height 35.5 mm., length of aperture 27.1 mm., breadth of aperture 12.9 mm.
(figured specimen collected from off Iwate Pref., Honshu by Mr. Ryosuke KAWAMURA).

Type locality: Shito, Ichihara gun, Chiba Pref., Honshu. (fossil).

Distribution: Hokkaido and Northern Honshu.

Tugali (?) *gigas* (v. MARTENS)

(Pl. II, Figs. 34)

- 1881 *Submarginula gigas* v. MARTENS, Conch. Mittheil., **2**, p. 103, pl. 19.
 1890 *Submarginula gigas* PILSBRY, Man. Conch., **12**, p. 286.
 1915 *Emarginula (Tugalia) gigas* THIELE, Conch. Cab., **2** (4a), p. 101, pl. 12, figs. 81, 8-10.
 1929 *Tugalia gigas* TOBA, Venus, **1** (5), p. 194.
 1947 *Tugali gigas* HIRASE et KURODA, Illust. Encycl. Fauna Japan (rev. ed.), p. 1193, fig. 3400.
 1951 *Tugali gigas* Is. TAKI, HIRASE's Handb. Illust. Shells, pl. 63, fig. 4.

Height 25.6 mm., length of aperture 93 mm., breadth of aperture 58.4 mm., (examined specimen collected from Iwate Pref., Honshu).

Height 21.6 mm., length of aperture 86.5 mm., breadth of aperture 52.9 mm. (figured specimen collected from Iwate Pref., Honshu).

Type locality: Northern Honshu.

Distribution: Northern Honshu and Hokkaido.

Genus *Tugalina* HABE 1953

1953 *Tugalina* HABE, *Illust. Cat. Jap. Shells*, **23**, p. 183.

Type species: *Tugalina radiata* HABE (monotypy).

Tugalina radiata HABE

(Pl. II, Fig. 2)

1953 *Tugalina radiata* HABE, *Illust. Cat. Jap. Shells*, **23**, p. 183.

Height 1.7 mm., length of aperture 14.5 mm., breadth of aperture 10.2 mm. (figured type specimen).

Height 2.0 mm., length of aperture 10.5 mm., breadth of aperture 8.0 mm. (paratype specimen).

Type locality: Okinawa, Ryukyu group.

Genus *Montfortula* IREDALE 1915

1915 *Montfortula* IREDALE, *Trans. Proc. New Zealand Inst.*, **47**, p. 433.

Type species: *Emarginula rugosa* QUOY et GAIMARD (original designation).

Montfortula pulchra (A. ADAMS)

(Pl. II, Fig. 7)

1852 *Emarginula pulchra* A. ADAMS, *Proc. Zool. Soc. London*, **19**, p. 85.

1863 *Emarginula pulchra* A. ADAMS, *Thes. Conch.*, **3** p. 219, pl. 246, figs. 50, 51.

1860 *Emarginula picta* DUNKER, *Mal. Bl.*, **6** p. 226.

1861 *Emarginula picta* DUNKER, *Moll. Jap.*, p. 23, pl. 3, fig. 5.

1874 *Emarginula pulchra* SOWERBY, *Conch. Icon.*, **9**, *Emarginula*, pl. 2, fig. 7.

1890 *Subemarginula pulchra* PILSBRY, *Man. Conch.*, **12**, p. 282, pl. 28, fig. 28.

1916 *Clypidina pulchra* THIELE, *Conch. Cab.*, **2** (4a), p. 132, pl. 15, fig. 11.

1926 *Subemarginula cratitoides* YOKOYAMA, *Jour. Coll. Sci. Imp. Univ. Tokyo*, **45**, p. 36, pl. 2, fig. 10.

1945 *Clypidina* (*Montfortula*) *pulchra* HABE, *Jap. Jour. Malac.*, **14**, pl. 1, fig. 1.

1951 *Clypidina picta* Is. TAKI, HIRASE's *Handb. Illust. Shells*, pl. 63, fig. 3.

Height 6.3 mm., length of aperture 13 mm., breadth of aperture 9.6 mm.
(figured specimen collected from Shirahama, Wakayama Pref., Honshu).

Height 8.1 mm., length of aperture 13.4 mm., breadth of aperture 9.6 mm.
(examined specimen collected from Kochi Pref., Shikoku).

Type locality: Isle of Camaguan, Philippines (on exposed rocks, lower water).

Distribution: Philippines; Kyushu; Shikoku and Honshu.

Montfortula (pulchra var.) polygonalis (A. ADAMS)

(Pl. II, Figs. 8, 9)

1952 *Emarginula polygonalis* A. ADAMS, Proc. Zool. Soc. London, **19**, p. 91.

1862 *Emarginula (Clypidina) textilis* GOULD, Proc. Boston Soc. Nat. Hist., **7**, p. 163.

1863 *Emarginula polygonalis* A. ADAMS, Thes. Conch., **3**, p. 217, pl. 247, fig. 78; pl. 248, fig. 90.

1873 *Emarginula polygonalis* SOWERBY, Conch. Icon., **19**, *Emarginula*, pl. 2, fig. 6.

1890 *Subemarginula (Clypidina) polygonalis* PILSBRY, Man. Conch., **12**, p. 281, pl. 29, figs. 34, 35.

1916 *Hemitoma polygonalis* THIELE, Conch. Cab., **2** (4a), p. 117, pl. 15, fig. 5.

Height 7.3 mm., length of aperture 13.2 mm., breadth of aperture 9.6 mm.
(figured specimen collected from Tokunoshima, Amami group).

Type locality: Catuanan, Philippines.

Distribution: Philippines, Ryukyu and Amami groups.

Genus *Montfortia* RÉCLUZ 1843

1843 *Montfortia* RÉCLUZ, Rev. Zool., p. 259.

Type species: *Emarginula australis* QUOY et GAIMARD (designated by Iredale 1915).

Montfortia oldhamiana (NEVILL)

(Pl. II, Figs. 18, 19)

1869 *Emarginula oldhamiana* NEVILL, Jour. Asiat. Soc. Bengal, **38**, p. 162, pl. 17, fig. 17.

1873 *Emarginula oldhamiana* SOWERBY, Conch. Icon., **19**, *Emarginula*, fig. 69.

1890 *Subemarginula oldhamiana* PILSBRY, Man. Conch., **12**, p. 277, pl. 41, figs. 32, 33.

1916 *Hemitoma oldhamiana* THIELE, Conch. Icon, **2** (4a), p. 117, pl. 13, fig. 18.

Height 8.7 mm., length of aperture 14 mm., breadth of aperture 9.5 mm.
(figured specimen collected from Shirahama, Wakayama Pref., Honshu).

Type locality: Ceylon.

Distribution: Ceylon and Wakayama Pref., Honshu.

Subgenus *Montfortista* IREDALE 1919

1929 *Montfortista* IREDALE, Mem. Queensland Mus., 9 (3), p. 269.

Type species: *Montfortia excentrica* IREDALE (original designation).

Montfortia (*Montfortista*) *panhi* (QUOY et GAIMARD)

(Pl. II, Figs. 27, 28)

1834 *Emarginula panhi* QUOY et GAIMARD, Voy. de l' Astrol., p. 327, pl. 68, figs. 7. 8.

1850 *Emarginula clathrata* A. ADAMS et REEVE, Voy. Samarang, Moll., p. 69, pl. 11, fig. 6.

1852 *Submarginula panhiensis* ADAMS, Proc. Zool. Soc. London, 19, p. 90.

1863 *Emarginula panhiensis* SOWERBY, Thes. Conch., 3, p. 218, pl. 247, figs. 73, 74, 75.

1873 *Emarginula panhiensis* SOWERBY, Conch. Icon., 19, *Emarginula*, pl. 6, fig. 43.

1890 *Emarginula tricarinata* PILSBRY, Man. Conch., 12, p. 277, pl. 29, figs. 73-79.

1916 *Hemitoma panhiensis* THIELE, Conch. Cab., 2 (4a), p. 116, pl. 13, figs. 12, 13.

1947 *Hemitoma* (*Montfortista*) *panhi* HIRASE et KURODA, Illust. Encycl. Fauna Japan (rev. ed), p. 1194, fig. 3402.

1951 *Hemitoma panhi* Is. TAKI, HIRASE's Handb. Illust. Shells, pl. 63, fig. 2.

Height 11.4 mm., length of aperture 18.3 mm., breadth of aperture 13 mm. (the largest examined specimen collected from Ryukyu group by Mr. A. TERAMACHI).

Height 9.8 mm., length of aperture 16.1 mm., breadth of aperture 8.7 mm. (examined specimen from the same locality).

Height 8.4 mm., length of aperture 14.6 mm., breadth of aperture 8.5 mm. (figured specimen from the same locality).

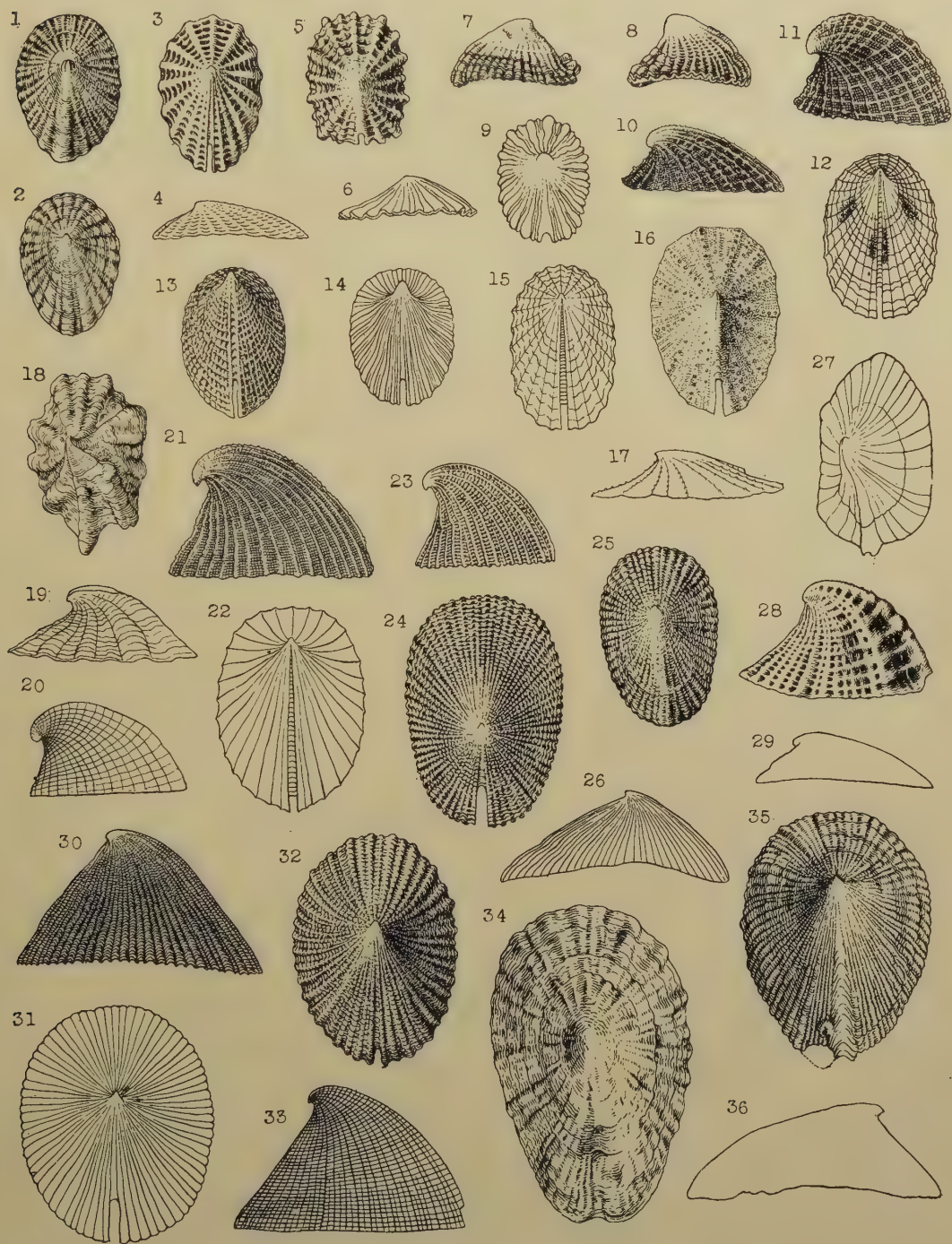
Type locality: Tonga Tabu, South Pacific Ocean.

Distribution: Tonga Tabu; Palao Island; Philippines; Ryukyu and Amami groups.

EXPLANATION OF PLATE II

(all figures unequally magnified)

- Fig. 1. *Tugali scutellaris* A. ADAMS.
2. *Tugalina radiata* HABE.
3, 4. *Emarginella eximia* (A. ADAMS).
5, 6. *Emarginella okinawaensis* n. sp. (type specimen).
7. *Montfortula pulchra* (A. ADAMS).
8, 9. *Montfortula* (*pulchra* var.) *polygonalis* (A. ADAMS).
10, 15. *Emarginula concinna* A. ADAMS.
11, 12. *Emarginula compta* n. sp. (type specimen).
13, 20. *Emarginula hataii* n. sp. (type specimen).
14, 23. *Emarginula teramachii* n. sp. (type specimen).
16, 17. *Laeviemarginula membranacea* HABE (type specimen).
18, 19. *Montfortia oldhamiana* (NEVILL).
21, 22. *Emarginula fragilis* (YOKOYAMA).
24, 26. *Emarginella planulata* (A. ADAMS).
25, 29. *Tugali decussata* (A. ADAMS).
27, 28. *Montfortia* (*Montfortista*) *panhi* (QUOY et GAIMARD).
30, 31. *Emarginula regia* n. sp. (type specimen).
32, 33. *Emarginula fujitai* n. sp. (type specimen).
34. *Tugali* (?) *gigas* (V. MARTENS).
35, 36. *Tugali vadososinuata* (YOKOYAMA).



T. HABE: FISSURELLIDAE IN JAPAN (2).

**LERNAEENICUS QUADRILOBATUS N. SP. (COPEPODA,
LERNAEIDAE) PARASITIC ON THE LANTERN-FISH
DIAPHUS COERULEUS***

SATYŪ YAMAGUTI

Zoological Institute, Kyoto University, Kyoto

AND

HUZIO UTINOMI

Seto Marine Biological Laboratory, Sirahama

With one Text-figure

A single gravid female of this species was found on a lantern-fish, *Diaphus coeruleus* KLUNZINGER caught by Mr. S. URA of the Seto Laboratory in Tanabe Bay on November 16, 1952, with its cephalothorax and neck completely embedded in the flesh on the right side between the operculum and the dorsal fin.

Holotype: A gravid female. Reg. No. 120, preserved in the museum of the Seto Marine Biological Laboratory.

Body divided into cephalothorax, neck, trunk and abdomen, 17.1 mm in total length. Cephalothorax: 1.8 mm long by 2.1 mm broad; head end broadly rounded, with dark purple spots of irregular outline behind base of antennae, and a median eye-spot 0.35 mm posterior to frontal margin. On either side of the cephalothorax there are two rounded protuberances one directly behind the other, the larger anterior measuring about 0.9 mm and the posterior about 0.75 mm in diameter at the base.

On the dorsal aspect the head proper is separated on each side from the above-mentioned lateral lobe by an outwardly convex longitudinal groove, and completely fused with the first thoracic segment, whose conical posterolateral corner bears a minute blunt-pointed papilliform projection; the second, third and fourth thoracic segments are clearly indicated by their prominent chitinous dorsolateral ridges, whose posterior corner is rounded in the second and third segments but produced into a conical tooth in the fourth segment; the transverse

* Contributions from the Seto Marine Biological Laboratory, No. 201.

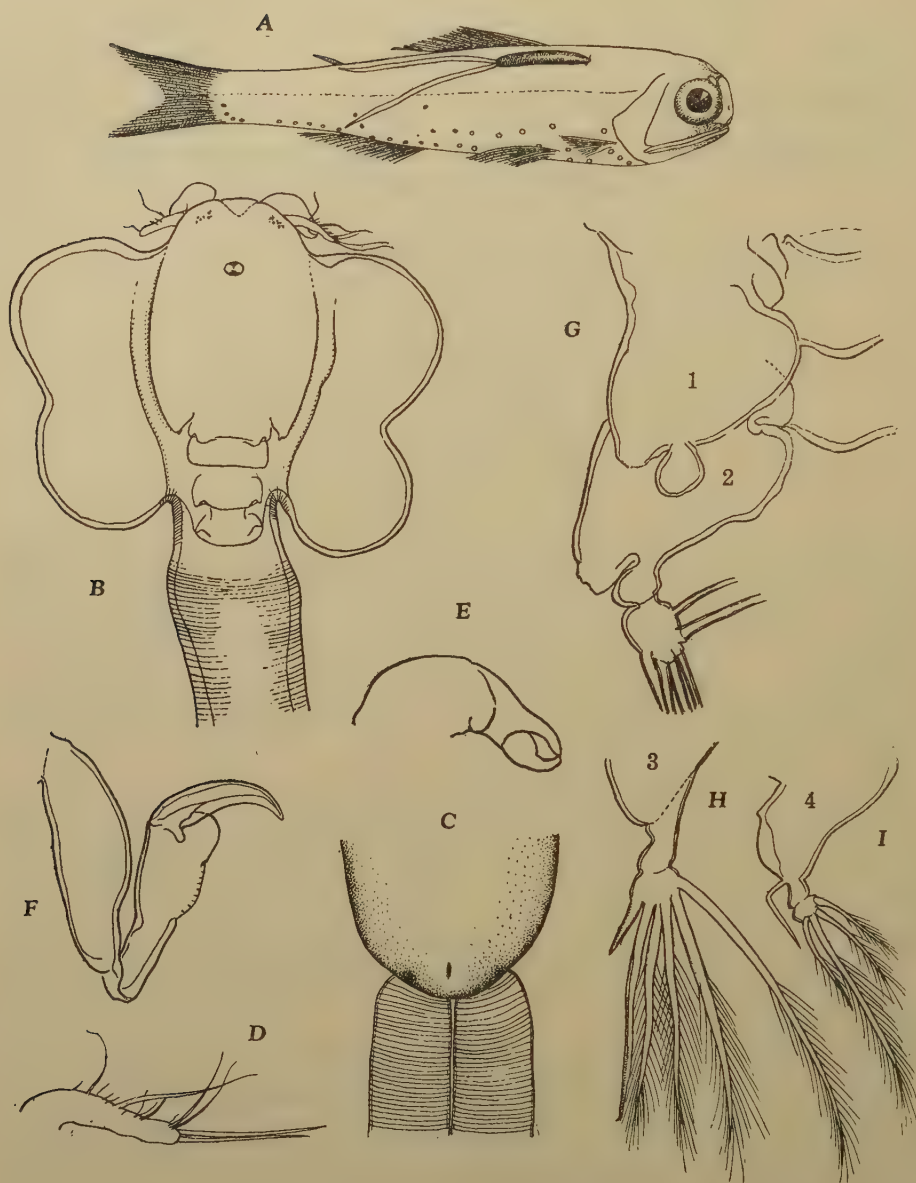


Fig. 1. *Lernaeenicus quadrilobatus* n. sp.

A, female (holotype) parasitic on *Diaphus coeruleus* Klunz. $\times 1.3$. B, dorsal view of cephalothorax. $\times 27$. C, dorsal view of posterior part of trunk. $\times 18$. D, first antenna. $\times 80$. E, second antenna. $\times 80$. F, second maxilla. $\times 150$. G, first and second legs on the right side, the outer rami being missing. $\times 150$. H, third leg. $\times 150$. I, fourth leg. $\times 150$.

posterior margin of each segment is also fairly well marked out. Neck slender, curved 6.3 mm long, somewhat contracted at the anterior end where the swimming legs are attached, and a little swollen at a point about one-third the length of the neck from its posterior end. Trunk cylindrical, straight, 9 mm long by 2 mm wide, dull brown, slightly increasing in diameter posteriorly. Abdomen rudimentary, forming a mere hemispherical protuberance. Egg strings 16 mm long and 0.6 mm wide; eggs uniseriate, strongly flattened.

Appendages: First antenna cylindrical, 0.28 mm long, directed obliquely backwards, indistinctly separable into three portions, with a few long and many fine setae along anterior margin, two long setae at tip and four more subterminally. Second antenna two-segmented, with its stout base projecting forward beyond base of first antenna, second segment chelate. Fringed chitinous margin of mouth cone notched medially at anterior end, 0.275 mm in diameter. First maxilla rather slender, tipped with two unequal setae. Second maxilla three-segmented, basal segment stout, longer than middle segment, terminal segment forming a claw shorter than middle segment. Of the four pairs of swimming legs the first two are biramous and the last two uniramous. All rami two-segmented. Unfortunately most of the rami are missing except for the right inner ramus of the second leg, whose terminal segment bears six plumose setae along distal and inner margin. Terminal segment of third leg with two unequal, pectinate spines and four plumose setae, that of fourth leg with four plumose setae only.

This species is distinguished from any of the known members of the genus by the cephalothorax possessing two large rounded lobes on each side. The specific name refers to this character. So far as we are aware, all the known species of *Lernaeenicus* are usually furnished with one pair of horn-like lateral projections on the cephalothorax.

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——— 1934. The Copepoda of the Siboga Expedition. Part II. Commensals and parasitic Copepoda. Siboga-Expeditie, Mon. 29b.
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KIRTISINGHE, P. 1932. Two new parasitic copepods from Ceylon. Parasitology, 24, No. 4.
SCOTT, T. & A. SCOTT 1913. The British parasitic Copepoda. Ray Society, London.
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DROPLETS FROM THE PLANKTON NET
XI. A NEW TYPE OF *LITTORINA-CAPSULA**

TAKASI TOKIOKA and TADASHIGE HABE

(Fig. 11)

A new type of egg capsule of littorinid was found on a slide under the microscope while a plankton sample hauled near the Laboratory in Tanabe Bay was studied. It differs distinctly from any form hitherto recorded in its gear-like outline.

It is roughly disc-shaped, ca. 160μ in diameter and 50μ in thickness, and bears an appearance like a gear consisting of 21 teeth. The upper side swells up 40μ in the form of a cone which is provided with two concentric ridges and probably has an opening at the tip. The under side is quite flat. The capsule is colourless and contains an egg, ca. 80μ in diameter.

The present new type is named *Littorina-capsula hagruma* nov. from its characteristic gear-like appearance (Haguruma, *Jap.* = gear).

We have got three types of *Littorina-capsula* from the Japanese waters, which show each a characteristic feature common to all of them; the presence of a few concentric ridges on the upper surface of the capsule. Egg capsules of littorinids known by this date may be classified into the following three groups:

(1) Helmet-shaped.

Littorina littorea L. (LEBOUR 1935)

Littorina pintado WOOD (OSTERGAARD 1950)

(2) Simple drum-shaped.

Littorina (Melaraphe) neritoides (MONTAGU) (LEBOUR 1935)

Tectarius muricatus (LINNÉ) (LEBOUR 1945)

(3) Drum-shaped, with ridges on the swollen upper side.

Littorina zigzac "DILLWYN" (GMELIN) (LEBOUR 1945)

Echinella trochiformis (DILLWYN) [= *Tectarius* (*Nodilittorina*)
tuberculatus (WOOD)] (LEBOUR 1945)

* Contributions from the Seto Marine Biological Laboratory, No. 202.

Littorina-capsula habei (TOKIOKA 1950)

Littorina-capsula multistriata (TOKIOKA 1950)

Littorina-capsula hagruma nov.

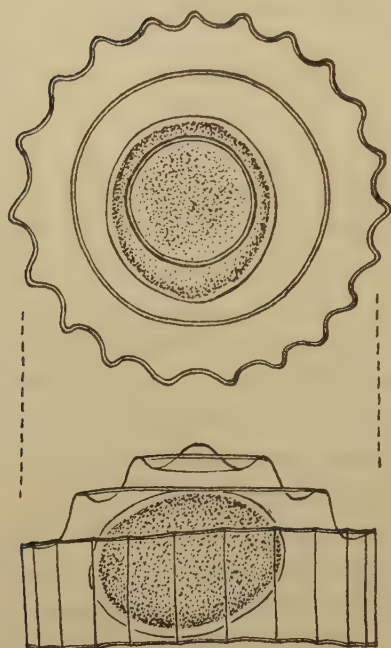


Fig. 11. *Littorina-capsula hagruma* nov. $\times 300$

Three Japanese types are all included in the third group and form in it a sub-group on account of the existence of *concentric* ridges instead of *spiral* ones in two forms described by LEBOUR on Bermudian littorinids. These are not yet combined with any species of Japanese littorinids, although *Tectarius* (*Nodilittorina*) *granularis* (GRAY) is the commonest species in this region. The identification of Japanese littorinids seems to need reconsultation, if the shape of egg capsule means an important systematic significance.

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XII. RECORD OF *RECLUZIA MONTROUZIERI* BRAZIER NEAR SETO

TADASHIGE HABE and TAKASI TOKIOKA

(Figs. 12 and 13)

A specimen of *Recluzia montrouzieri* BRAZIER was offered to our examination by the courtesy of Mr. S. KINOSITA, a conchologist in the town of Sirahama. This floating snail was found on the shore along this town in the summer of 1950, being dead, but not yet losing its soft body.



Fig. 12. *Recluzia montrouzieri* BRAZIER.
Left—Front view of shell, Right—Apical view of shell.
× ca. 6.

Recluzia montrouzieri BRAZIER

- 1871 *Recluzia montrouzieri* BRAZIER, Jour. de Conchyl., 19, p. 334.
1872 *Recluzia montrouzieri* BRAZIER, Jour. de Conchyl., 20, p. 57, Pl. I, fig. 8.

Shell ovate-oblong, thin, fragile, yellowish brown in colour except the

embryonal shell which is brown; spire elevated; whorls five in number, each whorl very convex and suture decidedly deep; body whorl very large, occupying about four-fifths of the shell length; surface with the weak growth lines and very faint several spiral threads on the peripheral and basal areas; aperture also large and ovate in shape; outer margin roundly arcuate and simple, columellar margin white, thickened and reflexed; umbilicus very narrow and deep, but in the perfect specimen may be nearly closed by the hyaline membrane caused by the dilation of the columellar margin; parietal wall enamel weakly.



Fig. 13. *Recluzia montrouzieri* BRAZIER.
 a—Two teeth from radula, magnified.
 b—Float, enlarged.
 c—Foot, enlarged.

Height 14.2 mm, breadth 10 mm, height of aperture 9.1 mm, breadth of aperture 6.8 mm.

Radula of the ptenoglossate type, all the teeth are elongated and attenuated and incurved at the distal end (Text-fig. 13 a). Each transverse row consists of about forty teeth which increase in size outwardly, measuring ca. 0.18 mm at the outer-most one. Foot spatulate, ca. 3 mm in length. Float roundly oval in outline, 9 mm long $\times$ 7 mm wide $\times$ 3–4 mm thick and dark brownish in colour. It consists of many small, 0.7–1 mm in diameter, permanent froths and embraced tightly with a thin 10 mm long string stretching out of the foot.

It seems very interesting to examine the weight of this floating snail.

Weight of shell.....0.118 gr.

Weight of soft body including float...0.186 gr.

0.304 gr.

A small float of 0.22 cc in volume seems to be enough to keep floating of this snail, ca. 0.3 gr. in weight in the air.

All the specimens belonging to the genus *Recluzia*, collected from the Japanese waters by this date, in Sagami Bay, Kusimoto and Sirahama in southern Wakayama Pref. in Honsyu and Kagosima Pref. in Kyusyu, have been recorded as *R. bensoni* A. ADAMS which was reported originally from China Sea off Formosa. The present specimen is, however, quite disagreeable with *R. bensoni*, the type specimen of which is preserved in the British Museum and figured by Mr. T. CH. YEN, but seems rather to conform well with *R. montrouzieri* BRAZIER from Island of Art, New Caledonia, in the appearance of the shell which has higher spire than in *R. bensoni* and has the nearly closed umbilicus.

ON THE VERTICAL DISTRIBUTION OF ANIMAL PLANKTON IN THE SEA OF JAPAN OFF SAN'IN-DISTRICT IN SUMMER OF 1952

KENZÔ FURUHASHI
Maizuru Marine Observatory, Maizuru

With 4 Text-figures and 2 Tables

Thirteen vertical hauls of plankton in daytime from the surface to the depth of nearly 500 m. were made at four stations 20 or 30 miles off San'in

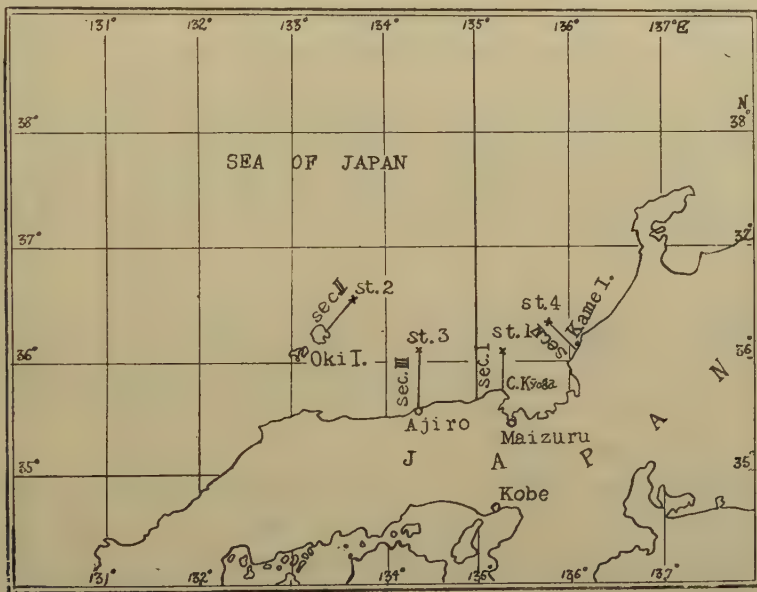


Fig. 1. Map showing the stations.

district in the Sea of Japan in the summer of 1952 (Fig. 1). A KITAHARA's quantitative net (20 cm. in mouth diameter and stretched with bolting silk No. 13—129 meshes per inch) was towed vertically from 50 m. to the surface at

each station, and at the same time a large closing net (40 cm. in diameter, 2 m. in length and stretched with bolting silk No. 5—66 meshes per inch) was towed vertically in step method in layers deeper than 50 m.. All the data obtained during the observations are given in Table 2 at the end of this article.

As we have not yet full knowledge about the distribution of animal plankton in deeper water of the area mentioned above, the author wishes to give herein some brief notes on animal plankton found in hauls and also on the relation between the vertical distribution of the animals and the hydrographical condition.

The author is indebted much to Dr. K. HISHIDA and Mr. I. NAKAYAMA of Maizuru Marine Observatory and to the crew of the "Kuroshio Maru" throughout the work to whom he wishes to express here his hearty thanks. He is also very grateful to Dr. T. TOKIOKA for his kind advices and generous encouragement given during the work.

Observations

I. Qualitative analysis of animal plankton

Seventy-five of 125 species of animal plankton identified during the observations, are occupied by copepods including some larval stages. The rest consists of 12 species of Chaetognatha and 38 species belonging to other animal groups. In the following, brief notes are given on some important species in deeper waters.

Copepoda:

1) *Calanus cristatus*: Totally 34 immature females were collected during the work. Some adults are previously reported by TANAKA (1938) from the deep layer under 500 m. in Sagami Bay and by NAKAI (1942) from the deep layer (1000–2000 m.) of Japan Sea.

2) *Calanus plumchrus*: The author already reported many immature females from the deep water of this area in 1951. A few mature females and a number of male were found during the present work.

3) *Eucalanus giesbrechti*: Seven males, together with some females, were found in the collection, although no male was found in last year.

4) *Gaetanus armiger*: Only one female was found in a haul from the deep layer at St. 8.

5) *Bradyidius armatus*: Twenty females were found in hauls from deeper layers.

6) *Euchaeta japonica*: Plenty of immature individuals and a few adult males and females were collected from deep layers under 250 m..

Pteropoda:

7) *Clione limacina*: This pteropod was found in a considerable number from the deeper layer at each station. The largest specimen reaches 5 mm. in length.

8) *Limacina helicina*: Distributed as in last year, but not so much.

Coelenterata:

9) *Aglantha digitale*: Caught from the layer deeper than 100 m..

10) A species of Agalmidae: Probably a few individuals were found only in middle layers. As they were found in fragments such as nectophores, bractus and other parts, it was difficult to identify the species or to count individuals accurately.

Chaetognatha:

11) *Sagitta elegans*: This form was found in a considerable number in deeper layers at each station.

The species mentioned above belong to cold water forms or at least to deep water forms.

As listed in Table 1, the main components of zooplankton at each station and in each layer were copepods which occupy 85-95% of zooplankton except at St. 4. In the surface layer of St. 4, copepods decrease to 49.6% of zooplankton, on account of the occurrence of *Tintinnus* sp. in abundance (29.8%). The composition of copepods varies according to depth as will be mentioned in detail in the following paragraph.

The next commonest animals are tunicates in upper layers and crustaceans, excluding copepods, in deeper layers. In every sample from middle layers, fragments of an Agalmid form occurred abundantly.

II. Vertical distribution of animal plankton

During the present observation, the following 7 species were found only in the water shallower than 50 m.; *Acrocalanus gracilis*, *Labidocera japonica* and *Microsetella norvegica* of Copepoda, *Penilia schmackeri* of Phyllopoda, *Creseis acicula* of Pteropoda, *Sagitta regularis* and *S. neglecta* of Chaetognatha.

All species mentioned above belong to warm water forms.

At every station samplings were made at about the noon. These animals might be distributed even in deeper layers by the vertical dispersion, if the circumstances of the deep water permit them to survive. Thus, they are considered as typical species in the surface layer of warm Tsushima Current.

A few of the species found in samples from middle layers (100 m.-250 m.) are regarded as characteristic ones to the layers. They are *Ctenocalanus*

Table 1. Composition of Zooplankton. (% to the whole zooplankton)

Station	St. 1		St. 2		St. 3		St. 4	
Lat. (N) Long. (E)	36-06.5 135-14.0		36-32.0 133-39.0		36-05.2 134-17.8		36-31.5 135-41.5	
Date (1952)	July 3		July 19		July 23		Aug. 9	
Time	11,45-12,45		11,20-13,00		12,35-13,40		12,50-13,45	
	No. 1	No. 2	No. 3	No. 4	No. 1	No. 2	No. 3	No. 4*
Hauled Distance(M) (Angle)	50-0 (30°)	210-55 (38°)	350-190 (40°)	550-250 (26°)	50-0 (15°)	100-50 (15°)	250-90 (16°)	500-200 (16°)
Hauled Depth (M)	43-0	166-43	268-146	494-225	48-0	97-48	240-87	500-206 (491-196)
Copepoda	90.6	95.4	90.8	84.9	86.1	93.0	91.2	88.6
Crustacea	—	2.7	2.9	12.6	1.2	0.4	4.1	5.5
Pteropoda	—	0.3	0.9	1.1	0.3	—	—	0.3
Coelenterata	—	0.0	0.6	0.4	—	—	0.2	0.2
Chaetognatha	0.0	0.0	0.5	0.4	2.2	0.1	0.6	0.3
Tunicata	8.7	1.3	0.9	—	6.2	0.8	0.7	0.2
Protozoa	0.5	—	2.2	0.2	2.6	1.3	1.9	0.8
Larva	0.2	0.3	1.2	0.4	1.4	4.4	1.3	0.4

* Estimated from the values of Nos. 2 and 3 at St. 4 hauled in step method.

longicornis of Copepoda, an Agalmid form of Coelenterata, *Sagitta serratodentata* of Chaetognatha and *Fritillaria borealis* of Tunicata.

The deeper water contained numerous species, of which 10 species were collected from the depth deeper than 200 m., while several other species were distributed widely in the range from 100 m. to 500 m.. Main species found regularly in deep water samples are listed next (Those with asterisk, show a widely distributed species):

Copepoda	Schizopoda
1. <i>Calanus cristatus</i> ♀	14. a species of Mysidacea*
2. <i>Calanus plumchrus</i> * ♀, ♂	15. a species of Euphausiacea
3. <i>Eucalanus giesbrechti</i> * ♀, ♂	
4. <i>Eucalanus attenuatus</i> * ♀	Pteropoda
5. <i>Pseudocalanus minutus</i> * ♀, ♂	16. <i>Limacina helicina</i> *
6. <i>Pseudocalanus gracilis</i> ♀	17. <i>Clione limacina</i>
7. <i>Gaetanus armiger</i>	
8. <i>Bradyidius armatus</i>	Coelenterata
9. <i>Stephus</i> sp.	18. <i>Aglantha digitale</i> *
10. <i>Scoreithricella minor</i>	
11. <i>Euchaeta japonica</i> * ♀, ♂	Chaetognatha
12. <i>Metridia lucens</i> * ♀, ♂	19. <i>Sagitta elegans</i> *
13. <i>Oncaea conifera</i> *	

It is interesting that some of the species show different distribution between sexes. For instance, females of *Calanus plumchrus* are distributed more deeply than males, but the relation is quite inverse in *Metridia lucens*. Most of the other species in the above-mentioned list are distributed more widely or rather irregularly.

Figure 2 indicates the vertical distribution of 9 species at St. 2. These species showed each an interesting distribution. The author made this figure assuming the equality of the filtering coefficients of KITAHARA's vertical net and the large closing net. The blackened area is proportional to the individual number of each species. The vertical distribution of the water temperature is given on the right hand in the figure.

It seems to be useful to give some brief notes on each of these 9 species in the following.

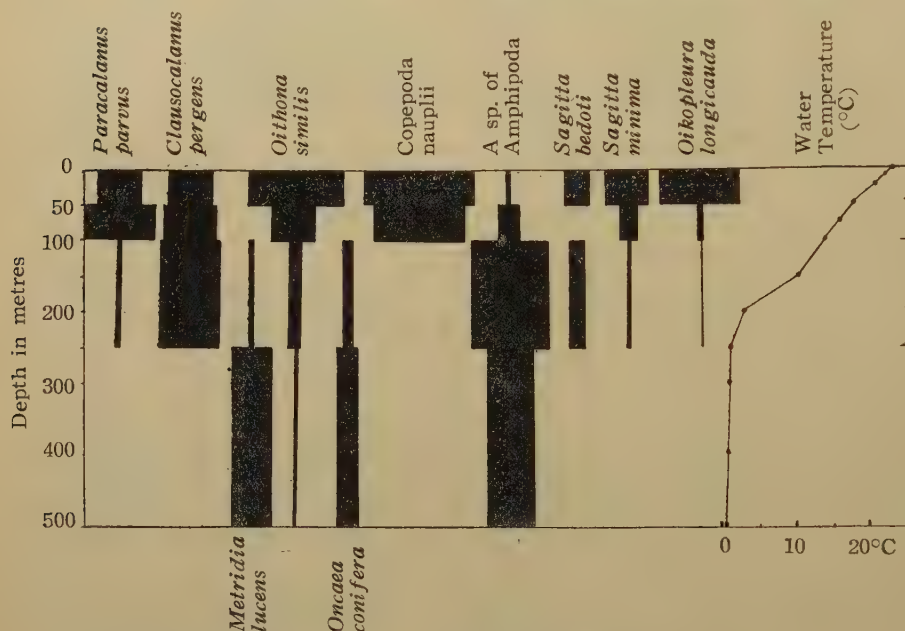
1) *Paracalanus parvus* is known to distribute in the surface layer. In the present data its densest population is found in the layer between 50 m. to 100 m.. This distribution seems to be too deep for the species, but it may be understood

reasonably if we notice the fact that the distribution of this species covers the wide range of the water temperature from 7–8°C to 25°C and that the sampling was made in daytime of midsummer. Similar distribution of this species is reported by MOTODA and ANRAKU (1952) in the study of Funka Bay.

2) *Clausocalanus pergens* was distributed uniformly from the surface to 250 m.. This distribution agrees well with the result obtained by MOTODA and ANRAKU (1951) in Ishikari Bay. This species seems to distribute in the water temperature from 7–8°C to 20°C.

3) *Metridia lucens* females were distributed in the layer deeper than 200 m., while males were distributed more widely. The data obtained at St. 1

Fig. 2. Vertical distribution of important animal planktons at St. 2.



shows the possibility that males were distributed in the water deeper than 150 m., where the temperature was below 10°C.

4) *Oithona similis* was found abundantly in the surface layer shallower 50 m., although the deepest limit of distribution reached 500 m.. *Oithona plumifera* showed the same distribution as in the previous species.

5) *Oncaea conifera* has been said to be a species usually found in a small quantity in the surface layer of Tsushima Current. The present observation, however, reveals that its range is wider and extends down to the layer deeper than 200 m. where the temperature is below 8°C.

6) Nauplii of copepods were distributed abundantly in the layer shallower than 100 m., but no individual was found in layers deeper than 100 m..

7) A species of Hyperiidæ was widely distributed from the surface to 500 m., but mainly in the layer deeper than 100 m.. It may be noteworthy that all individuals found in surface layers were immature, while those found in deeper layers were mostly mature reaching beyond 10 mm. in length.

8) *Sagitta bedoti* was distributed as in the previous species; namely immature individuals were found in the layer shallower than 50 m. and adults in deeper layers from 100 m. to 250 m.. It was a curious phenomenon that no individual of this species was found in the middle layer from 50 m. to 100 m.. Such a manner of distribution was observed not only at St. 2, but also at other stations. As to the chaetognaths fauna in the surface layer of the studied area refer the paper of TOKIOKA (1951).

9) *Oikopleura longicauda* was concentrated in the layer shallower than 50 m., although a few individuals were found also in deeper layer. Taking the result obtained at St. 1 into consideration, this species may live largely in the layer shallower than 150 m., where the temperature is beyond 10°C.

III. Distribution of animal plankton in relation to some hydrographical conditions

a) Significance of the depth.

At first, we must take into consideration that in this area the cold water mass of the temperature below 1°C lies under the warm Tsushima Current. Consequently the range of the distribution of animal plankton in this area does not represent the range in the area where the water is considered of uniform character. *Clione limacina* and *Limacina helicina* of Pteropoda, *Sagitta elegans* of Chaetognatha and *Calanus plumchrus* of Copepoda are all known to show the maximum density in the surface layer in cold waters (KOKUBO, 1932; TOKIOKA, 1940; MOTODA & ANRAKU, 1951).

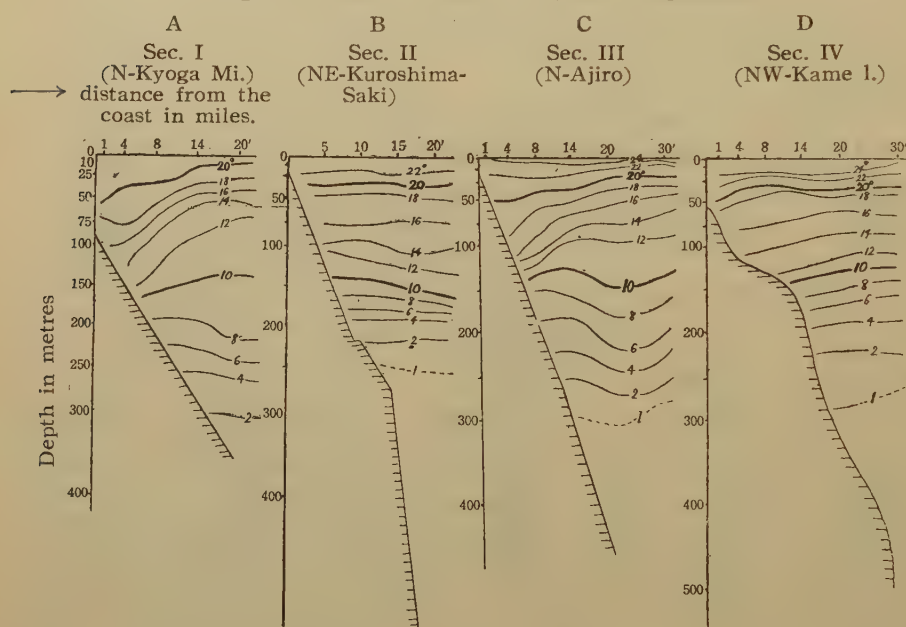
In this area, however, they are distributed in the layer deeper than 200 m. or 250 m., where the temperature is below 8°C. It is clear that the depth itself does not play any essential rôle limiting the vertical distribution of cold water animals in this area, although it may control effectively the vertical distribution of warm water animals especially living in the surface layer.

b) Effect of vertical migration.

All samples were hauled in midday, consequently the distribution of most copepods and other animals capable of violent movement may be considered to show the deeper limit to survive under the present circumstances. Next, the

upper limit of distribution of the cold water forms should be taken into account. In summer of 1951, several plankton samples were hauled in the same area at the following stations in night, namely from sunset to dawn: six stations off Kyôga-misaki on July 31st and August 1st, one station off Kasumi on August 2nd and four stations off Echizen-misaki on July 18th and 19th. A net was towed at each station vertically from 50 m. to the surface. I found only warm water forms in these hauls; cold water forms are therefore considered to be unable to migrate into the upper layer by the vertical movement during night. The details shall be shown in Maizuru Jour. Ocean., Vol. II, No. 1 (in press).

Fig. 3. Vertical distribution of water temperature.



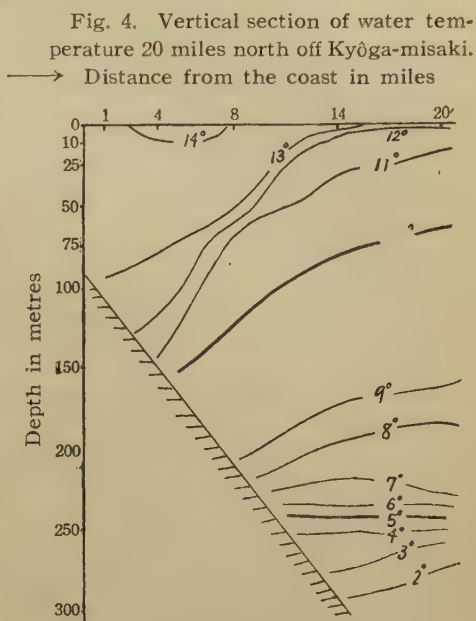
c) Effect of the water temperature.

One of the important factors controlling the unusual distribution of animal plankton in this area is probably the water temperature. Vertical distributions of the water temperature at four sections each containing one of four stations are shown in Fig. 3 (A-D).

As shown clearly in these figures, the temperature was 12°C.-25°C. in layers shallower than 100 m., where many warm water forms were found. The temperature dropped with depth below the level of 100 m. and reached 1°C. at the depth of about 300 m..

Most of warm water forms are considered to be impossible to survive in

deep cold layers. Actually the distribution of warm water forms was limited to the layer shallower than 100-150 m.. Cold water forms have never been found in a considerable number in any sample hauled in the layer shallower than 50 m. in this area during these four years since 1949, except in the following one case. In samples hauled in midday of May 1st. 1952 in the shallow water off Kyôga-misaki, immatured females of *Calanus plumchrus* were found in a considerable number, namely 2 at St. 3, 119 at St. 4 and 181 at St. 5, 20 miles off the coast. *Pseudocalanus minutus*, *Scorecithricella minor* and *Metridia lucens* were hauled at St. 4 and 5, where the isotherm of 11°C was raised to 50 m. layer as shown in Fig. 4. Such abnormal distribution of water temperature was not observed in this area even in winter (Maizuru Marine Observatory, 1952). Consulting the data mentioned above, the author wishes to propose provisionally that the upper limit of the distribution of cold water forms is situated approximately near the isotherm of 11°C. (Fig. 4).



Summary

Copepods occupied about 80% of the whole animal plankton in individual number and they were fairly distributed in response to the stratified water temperature. Some warm water forms were found in upper layers shallower than 50 m., where the temperature was over 18°C. Most of other warm water forms descended to the depth of 150 m., where the temperature was over 12°C. Many cold water forms were concentrated in deep layers under 200 m., where the temperature was below 8°C. The upper limit of the distribution of cold water forms was considered to be situated near the isotherm of 11°C. *Oithona similis* and *Oithona plumifera* were distributed throughout from the surface to the depth of about 500 m..

At any rate the vertical distribution of animal plankton in the area off San'in district is at the mercy of cold water mass lurking under the warm Tsushima Current.

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Table 2.

Numerals indicate the estimated total individual numbers calculated from the mean of countings on 3-6 slide materials (0.5 cc) of each sample. Those distinguished by parentheses are the total individual numbers actually counted. * see Table 1.

Individual number of the whole animal plankton	St. 1		St. 2		St. 3		St. 4	
	No. 1	No. 2	No. 3	No. 4	No. 1	No. 2	No. 1	No. 2
COPEPODA								
1. <i>Calanus cristatus</i> (immature)	35,992	63,089	7,451	19,295	12,703	17,794	20,552	25,391
2. <i>Cal. plumchris</i>	—	—	(1)	—	—	—	—	—
" "	—	(2)	(88)	(8)	(8)	(1)	(15)	(10)
3. <i>Cal. helgolandicus</i>	—	114	—	—	—	(7)	(446)	(310)
" "	—	—	—	(27)	(59)	—	(14)	(41)
4. <i>Cal. tenuicornis</i>	—	200	—	535	100	(11)	125	333
" "	—	—	—	(1)	(5)	—	(1)	—
5. <i>Cal. minor</i>	—	—	—	—	(7)	—	—	167
6. <i>Cal. juv.</i>	—	—	—	(2)	—	100	267	200
7. <i>Eucalanus giesbrechti</i>	—	—	—	—	—	—	100	(1)
" "	—	—	—	—	—	—	—	(3)
8. <i>Eu. attenuatus</i>	—	—	(2)	(8)	—	—	—	(10)
9. <i>Eu. crassus</i>	—	—	(3)	(4)	(7)	—	(1)	(1)
10. <i>Eu. micronatus</i>	—	—	—	(5)	(1)	(1)	—	(1)
11. <i>Rhincalanus nasutus</i>	—	—	—	—	—	—	—	—
12. <i>Acrocalanus gracilis</i>	—	—	—	(2)	—	—	—	—
13. <i>Paracalanus aculeatus</i>	—	—	—	—	—	—	—	—
14. <i>Para. pareus</i>	900	3,133	—	300	33	3,067	50	2,067
15. <i>Mecynocera clausi</i>	—	—	33	1,000	—	—	67	66
16. <i>Clausocalanus arcuicornis</i>	200	17,933	2,867	4,800	533	4,800	17	4,400
17. <i>C. pergens</i>	267	1,533	—	167	433	700	500	2,600
" "	—	600	—	67	133	—	—	—
18. <i>C. furcatus</i>	—	200	—	33	67	67	—	—
19. <i>Ctenocalanus longicornis</i>	—	—	100	—	—	—	—	—
20. <i>C. sp.</i>	—	—	—	133	—	—	933	267
21. <i>Pseudocalanus minutus</i>	—	—	—	—	—	—	—	—
" "	—	—	—	—	—	—	—	—
22. <i>P. gracilis</i>	—	—	—	—	—	—	—	—
23. <i>P. sp.</i>	—	—	—	—	—	—	—	—
24. <i>Gaelanus armiger</i>	—	200	133	—	—	33	(1)	(1)
" "	—	—	—	—	—	—	(3)	(2)
25. <i>G. sp.</i>	—	—	—	—	—	—	—	—
26. <i>Bradydium armatus</i>	—	—	—	(6)	—	—	(12)	(2)
" "	—	—	—	(29)	—	—	(20)	(2)

Table 2 (continued)

Individual number of the whole animal plankton	St. 1			St. 2			St. 3			St. 4		
	No. 1	No. 2	No. 3	No. 1	No. 2	No. 3	No. 1	No. 2	No. 3	No. 1	No. 2	No. 3 *No. 4
59. <i>Oithona similis</i> juv.	35,992	63,089	7,451	19,295	12,703	17,794	25,391	21,712	27,441	5,618	17,809	58,105 35,168
60. <i>O. conifera</i>	8,550	2,000	1,100	3,433	1,433	4,200	9,400	3,767	2,533	667	2,067	11,533 6,598
61. <i>Oncaea media</i>	1,850	—	—	667	366	—	733	—	—	50	—	—
62. <i>On. sp.</i>	—	67	—	—	—	333	—	67	1,767	—	—	1,100
63. <i>On. sp.</i>	100	167	—	267	833	33	133	833	—	33	1,033	667
64. <i>On. juv.</i>	33	—	—	1,700	+	100	967	133	—	117	300	3,867 3,100
65. <i>On. flaccus</i>	—	—	—	—	—	—	—	—	—	—	—	—
66. <i>Corycaeus trubicus</i>	—	—	—	—	—	—	(1)	—	—	—	—	67
67. <i>C. agilis</i>	—	—	—	—	—	—	33	—	—	—	—	—
68. <i>C. sp.</i>	—	—	—	(1)	133	+	—	—	—	—	33	100
69. <i>C. juv.</i>	—	—	133	33	+	—	—	—	—	—	—	—
70. <i>C. Podopleura</i> sp.	—	—	—	—	—	—	—	—	66	—	—	—
71. <i>A. sp. of Copepoda</i>	—	—	—	—	—	—	—	—	50	—	—	—
72. <i>other Copepods</i>	—	—	—	—	—	—	—	—	23	—	—	—
73. <i>Cope. nauplii</i>	13,650	67	—	3,967	3,233	—	3,100	1,567	—	1,017	67	200
74. <i>Cope. juv.</i>	6,850	31,130	900	4,300	4,133	3,667	3,733	3,800	9,867	317	4,500	18,800 13,032
CRUSTACEA VARIA												
76. <i>Evadne tergestina</i>	—	—	—	233	33	—	33	—	—	33	—	533
77. <i>Penilia schmackeri</i>	—	—	—	—	—	—	67	—	—	—	—	1,867
78. <i>Conchoecia</i> sp.	—	(1)	—	—	—	67	—	(1)	2,700	—	—	(4)
79. Mysidacean	—	—	(7)	—	—	(109)	—	(3)	(138)	—	—	(82)
80. Euphausiaceans sp.	—	—	—	—	—	—	—	—	527	—	—	386
81. <i>A. sp. of Hyperiid</i>	1,700	(208)	—	(1)	(15)	667	—	433	(4)	—	300	(11)
82. <i>other Hyperiid</i>	—	—	—	—	—	—	—	—	—	—	(4)	(7)
83. <i>Lucifer raynaudii</i>	—	—	—	—	—	—	—	—	—	—	—	—
PTEROPODA												
84. <i>Creseis acicula</i>	—	—	—	67	—	—	35	—	—	84	—	(89)
85. <i>Clione limacina</i>	—	(33)	—	—	—	—	—	—	225	—	—	(89)
86. <i>Limacina helicina</i>	186	—	33	—	—	—	—	67	—	—	—	(72)
COELENTERATA												
87. <i>Aglantha digitale</i>	—	—	(2)	—	—	(30)	—	—	(150)	—	+	(72)
88. Agalmidae sp.	—	+	—	—	—	—	—	—	—	—	—	—
89. Trachymedusae sp.	—	(9)	(37)	—	—	—	—	—	(7)	—	—	—
90. <i>Muggiaea</i> sp.	—	—	(1)	—	—	—	—	—	—	—	—	—
91. <i>M. sp.</i>	—	—	(3)	—	—	—	33	—	—	—	(1)	—
92. Hydromedusae	—	—	—	—	—	—	—	—	—	—	—	—

Table 2 (continued)

Individual number of the whole animal plankton	St. 1			St. 2			St. 3			St. 4		
	No. 1		No. 2	No. 3		No. 4	No. 1		No. 2	No. 3		No. 4
	35,992	63,089	7,451	19,295	12,703	17,794	20,552	25,391	21,712	27,441	5,618	17,809, 58,105, 35,168
CHAETOGNATHA												
93. <i>Sagitta elegans</i>	—	—	(30)	—	—	(6)	(71)	—	(1)	(35)	—	(86)
94. <i>S. enflata</i>	—	—	—	(3)	—	—	—	(2)	(2)	—	—	—
95. <i>S. bedoti</i>	(1)	(5)	(9)	(9)	—	(64)	—	(9)	(83)	—	(5)	(63)
96. <i>S. neglecta</i>	(1)	—	—	—	—	—	—	(1)	—	—	—	—
97. <i>S. minima</i>	(6)	(11)	—	(30)	(13)	(34)	—	(24)	(38)	—	(34)	(222)
98. <i>S. regularis</i>	—	—	—	(1)	—	—	—	—	(3)	—	—	—
99. <i>S. serratodentata</i>	—	—	—	—	—	—	—	—	(1)	—	—	—
100. <i>S. pseudoserratodentata</i>	—	—	—	—	—	—	—	—	—	—	—	—
101. <i>S. sp.</i>	—	—	—	—	—	—	—	—	—	—	—	(3)
102. <i>S. juv.</i>	—	—	—	373	—	—	—	205	—	—	150	500
103. <i>Pterosagitta draco</i>	—	—	(1)	—	—	—	—	(1)	—	—	—	—
104. <i>Krohnia pacifica</i>	—	—	—	—	—	—	—	—	—	—	—	—
TUNICATA												
105. <i>Oikopleura longicauda</i>	2,950	780	67	1,100	100	100	—	3,033	1,033	—	450	1,400
106. <i>O. fusiiformis</i>	—	40	—	33	—	—	—	233	—	—	84	133
107. <i>O. sp.</i>	167	—	—	67	—	—	—	300	—	33	317	—
108. <i>O. juv.</i>	—	—	—	—	—	33	—	—	—	—	—	67
109. <i>Fritillaria borealis</i>	—	—	—	—	—	—	—	—	—	—	50	66
110. <i>Doliolum nationalis</i>	—	—	—	—	—	—	—	—	—	—	—	—
PROTOZOA												
111. <i>Globigerina bulloides</i>	33	—	167	67	67	—	—	33	33	—	—	467
112. Foraminiferans	—	—	—	—	333	—	50	—	—	—	—	—
113. <i>Acanthometron pellucida</i>	—	—	—	267	—	—	—	33	—	—	—	—
114. Radiolarians	67	—	—	133	—	—	—	133	100	—	—	—
115. <i>Tintinnus</i> sp.	—	—	—	33	34	—	—	—	—	—	1,625	—
116. <i>Codonellopsis</i> sp.	—	—	—	—	—	—	—	—	—	—	33	—
117. <i>Rhabdonella</i> sp.	100	—	—	—	67	—	—	—	33	—	—	—
118. <i>Amphorella</i> sp.	—	—	—	—	—	—	—	—	—	—	17	—
LARVAL PLANKTON												
119. Balanus nauplius	—	—	—	—	133	—	—	—	33	—	—	—
120. Gastropoda velliger	67	—	—	—	300	167	75	100	133	—	—	100
121. Lamellibranchia velliger	—	—	—	167	—	—	—	133	67	33	—	66
122. Megalopa larva	—	—	(1)	—	—	—	—	—	—	—	—	(1)
123. Pluteus larva	—	133	50	100	100	—	—	—	—	—	—	—
124. Polychaeta larva	—	—	—	—	33	33	—	100	—	—	—	67
125. Fish eggs	—	20	(36)	—	—	33	+	—	—	100	—	—

PLANKTON INVESTIGATION IN INLET WATERS ALONG THE COAST OF JAPAN

VII. THE PLANKTON COLLECTED DURING THE CRUISES TO THE NEW YAMATO BANK IN THE JAPAN SEA*

ISAMU YAMAZI

Seto Marine Biological Laboratory, Sirahama

With 19 Text-figures

Introduction

During April, July and September of 1950, oceanographical surveys of the New Yamato Bank, a small fishing area lying northeast of Oki Bank, were carried out by the R. M. S. "Kurosio-Maru" of the Maizuru Marine Observatory under the leadership of Dr. Y. TOYOHARA, of the Institute of Geophysics of Kyoto University. During her cruises made in April and September, the writer himself had an opportunity to join the party to cooperate in the oceanographical works, and thus collected plankton samples at every station. Of these samples the pelagic tunicates and chaetognaths only have been taxonomically studied by Dr. TOKIOKA and a paper has already been published (TOKIOKA, 1951). The present paper deals with all these plankton samples, both quantitatively and qualitatively, in relation to the hydrological factors, which influence their habitat and distribution, and in connection here with the stability of the water masses indicated by the populations of some leading plankton animals.

The writer wishes to express his sincere thanks to Dr. Y. TOYOHARA and the officers on board of the Maizuru Marine Observatory for making this survey possible most effectively. Special thanks are due to Messrs. A. NAKAMURA, H. MAÉDA and S. FUSE of Kyoto University on board the ship for their help and courtesies in collecting the material. Further he desires to thank Prof. D. MIYADI, Dr. T. TOKIOKA, and in particular Dr. H. UTIMOMI who read the manuscript for their kind guidance and encouragement.

* Contributions from the Seto Marine Biological Laboratory, No. 203.

Collection and Analysis of Samples

Samples of plankton and hydrological data for the present study were obtained from the R. M. S. "Kurosio-maru", during three cruises from the Maizuru Bay to the New Yamato Bank, 70 miles off the cape Kyôga-saki (Fig. 1). The location of stations is shown in the key map (Fig. 2). At every station the surface plankton samples were hauled by means of TAMURA's cruise plankton collector (TAMURA, 1949) while sailing at a speed of 6 knots for periods of 3 to 10 minutes. This plankton collector, which is 2 cm and 8 cm in diameter of the mouth and largest part respectively and about 40 cm in length, is equipped

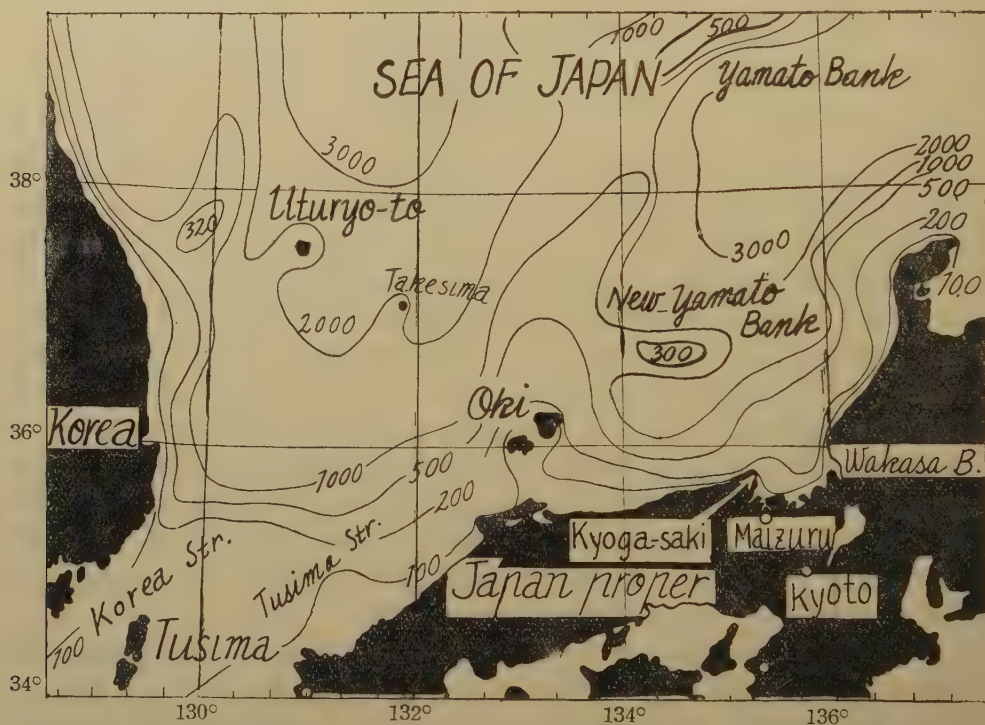


Fig. 1. Map of the southern Japan Sea showing the bathymetric contours and the position of stations referred to in the text.

with No. XX-13 MÜLLER's gauze. At some representative stations in each cruise (8 stations in the 1st cruise, 11 in the 2nd cruise and 6 in the 3rd cruise), plankton samples were vertically collected at about 50 m intervals from every layer (ranging between 50-350 m) to the surface with a KITAHARA's quantitative silk tow-net; this instrument shows ca. 22.5 cm in the mouth diameter and ca. 1 m

April 26-28, 1950

July 24-26, 1950

September 25-27, 1950



Fig. 2. The location of stations during three cruises to New Yamato Bank from Maizuru, in 1950.

long, and stretched with No. XX-13 MÜLLER's gauze. During the 2nd cruise in July, however, sampling with a closing net was also employed. The number of these stations with the hydrological data obtained is indicated in Figs. 3 & 4.

Standard hydrological observations for temperature, chlorinity, phosphates (P_2O_5), silicates (SiO_2), oxygen contents and catalytic activity of sea water were made vertically at these representative stations. SECCHI's disc measurements of transparency, FOREL's scale measurements of water color and pH of sea water were carried out during daylight stations. The methods herewith used for the determination of the catalytic activity of seawater, which is expressed by the reaction velocity of decomposing hydrogen peroxide, have been amply described (MATSUDAIRA, 1950, 1951), and for that reason will not be repeated here. In dealing with the populations of plankton, the large-sized animals, such as chaetognaths, tunicates and hydromedusae were separated from the remaining smaller forms in the laboratory. For each station the total number and settling volume of zoo- and phytoplankton, either or both, were calculated in each of samples per 10 minutes haul horizontally and per 10 meters haul vertically. The rough volume of every sample was measured with a measuring cylinder by settling method with 24 hours (YAMAZI, 1950).

Hydrological Conditions

1. First Cruise (April 26-28, 1950)

The hydrological condition along the line of stations observed during the first cruise from Maizuru Bay to the New Yamato Bank made in spring are shown in Figs. 3 and 4. The chlorinity from the surface to the 100-150 m layer was between 18.8 Cl ‰, (33.96 S ‰) and 19.1 ‰ (34.5 S ‰) and the temperature was between 6°C and 13°C. In the deeper water layer lower than about 150 m, the chlorinity was lower than in the upper layer, namely between 18.87 ‰ (34.09 S ‰) and 18.9 ‰ (34.1 S ‰), and the temperature between 6°C and 15°C. The coastal water extended superficially as far 5 miles off the coast (Kyôga-saki). We found the typical Tusima Current water with a chlorinity above 19.1 Cl ‰ (34.5 S ‰) and a temperature above 12°C flowing eastwards between the surface and the 100-150 m layer. The isotherm of 12°C was seen below the 50 m layer at St. 8 and St. 30, while on the 150 m layer at St. 20, 25 and 35 (Fig. 3 A). In Maizuru Bay, higher temperature (14°C) and lower chlorinity (16.58 Cl ‰ (29.95 S ‰)) was observed at the surface, while 13°C and 18.5 Cl ‰ (33.6 S ‰) at the 10 m bottom layer (Fig. 3, A-B). Within the bay, the contents of silicates in the

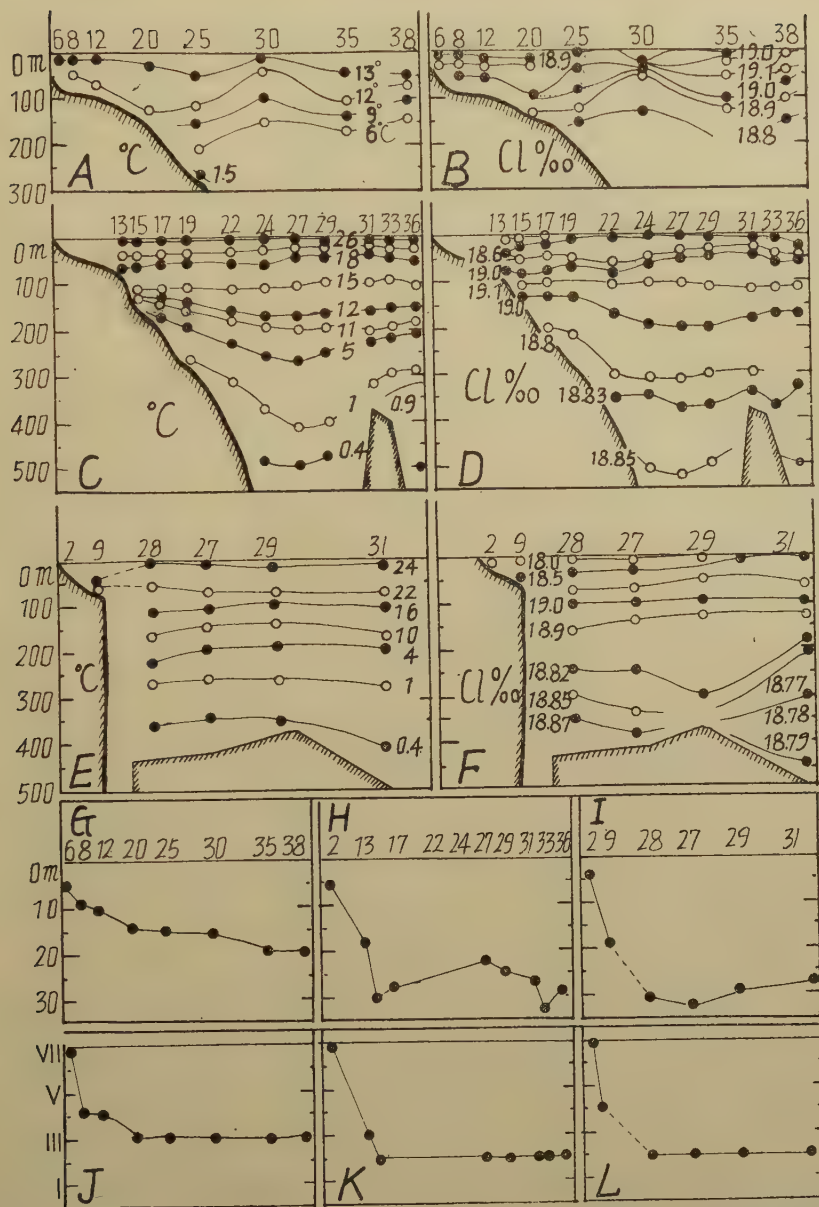


Fig. 3. Hydrological conditions from Maizuru Bay to New Yamato Bank during three cruises in 1950, no. 1.

A, C and E: Sectional distribution of water temperature in April, July and September, respectively.

B, D and F: Sectional distribution of chlorinity of sea water in April, July and September, respectively.

G, H and I: Distribution of transparency at section in April, July and September, respectively.

J, K and L: Distribution of water color at section in April, July and September, respectively.

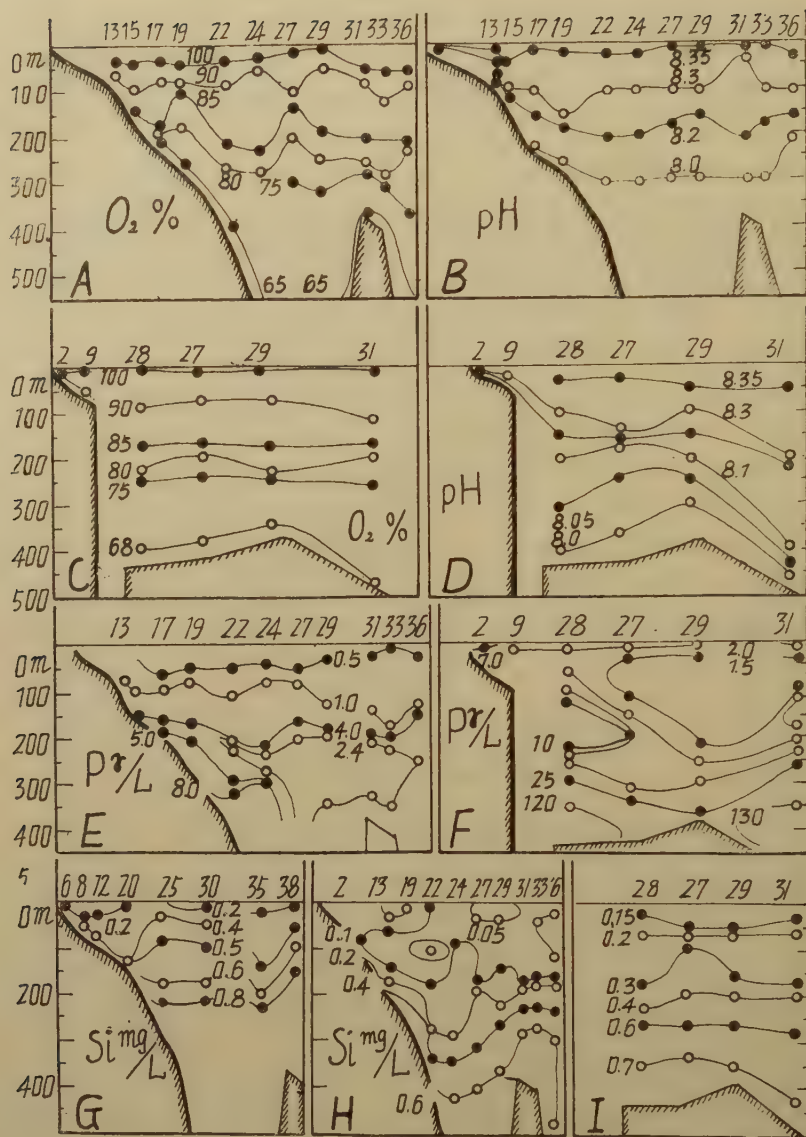


Fig. 4. Hydrological conditions from Maizuru Bay to New Yamato Bank during three cruises in 1950, no. 2.

A and C: Sectional distribution of percentage saturation degree of oxygen in July and September, respectively.

B and D: Sectional distribution of pH in July and September, respectively.

E and F: Sectional distribution of phosphate contents (P_2O_5 γ/L) in July and September, respectively.

G, H and I: Sectional distribution of silicate contents (SiO_2 mg/L) in April, July and September, respectively.

surface water showed lower values (about $200 \text{ mg/m}^3 \text{ SiO}_2$) than in the bottom water (about $500\text{--}800 \text{ mg/m}^3$) (Fig. 4, G). As deduced from the values of water color and transparency, the water of Maizuru Bay and Tango Bay (western part of Wakasa Bay) was comparatively turbid but the offshore water far distant from Tango Bay was clear (Fig. 3, G and J). The offshore water seemed to be, as a whole, rather turbid in spring compared with that in summer and autumn, since the smallest values for water color and for transparency were taken during this cruise.

2. Second Cruise (July 24-26, 1950)

In the second cruises undertaken during the mid-summer, the water showed higher temperatures and salinities over the whole area (Fig. 3, C, D). At stations off Kyôga-saki, the temperature was beyond 26°C , from the surface down to 25 m layer and that below 12°C was found only at a depth of 100 m. The isotherm for 12°C was laid at a depth of about 100 m in the coastal waters (St. 9 and 10) and of about 150 m in the offshore waters. The salinity of the surface layer was low, that is, 18.5 Cl ‰ (33.4 S ‰) near Kyôga-saki and 18.3 Cl ‰ (33.06 S ‰) only at St. 36 near the New Yamato Bank, although relatively high at all other stations. The isohaline of 19 Cl ‰ (34.3 S ‰) came up to between 100 and 150 m layer at the four coastal stations (St. 13, 15, 17 and 19), and between 150 and 200 meters at the offshore stations. The chlorinity lower than 19.0 Cl ‰ (34.3 S ‰) was found at 50 m upwards and about 200 m downwards. The isolines of the temperature, salinity and oxygen content under 150 meters rise slightly up along the continental shelf by upwelling of deeper water.

The horizontal and vertical distribution of dissolved oxygen content is shown in Fig. 4, A. The oxygen content was nearly uniform throughout all strata. The saturation degree of oxygen content was relatively high, more than 90 % (about 5.0 cc/L) at 100 m upward, 75 % (about 5.4 cc/L) at 300 m upward, and about 65 % (about 5.5 cc/L) in the bottom stratum of the continental shelf and on the New Yamato Bank at about 350 m depth. It is thus clear that the oxygen content is minimum at the surface and maximum at the depth of 150-300 meters. The pH value varied from 8.35 to 8.0, decreasing according to the depth (Fig. 4, B). The distribution of pH 8.3-8.35 was located at the depth from 0 to 100 m, the pH 8.0 at about 200 to 300 m. The phosphates and silicates were larger in the lower layer than in the upper layer (Fig. 4, E). These values varied $0.5\text{--}1.0 \text{ P}_2\text{O}_5 \text{ } \gamma/\text{L}$ and $50\text{--}100 \text{ SiO}_2 \text{ mg/L}$ between 0 and 100 m, $3\text{--}8 \text{ P}_2\text{O}_5 \text{ } \gamma/\text{L}$ and $2000\text{--}4000 \text{ SiO}_2 \text{ mg/L}$ between about 100 to 300 m, and $6000 \text{ SiO}_2 \text{ mg/L}$ at the lower layer. These values were comparatively lower than those observed in April at equivalent levels. The water color and transparency were No. 8 of FOREL's

scale and 5 m of SECCHI's disc respectively in Maizuru Bay, and No. 2 of FOREL's scale and about 25 to 30 m of SECCHI's disc respectively off Kyôga-saki (Figs. 3, H and K).

3. Third Cruise (September 25-28, 1950)

During the third cruise in autumn, the hydrological observations were made mainly at the stations located within the area of coastal water and also at the offshore stations near the Bank. The surface water temperature ranged from 23°C to 25°C at all stations. In the offshore water overlying the Bank, the temperature descends from the surface to the deeper layer uniformly anywhere, the 20°C isotherm lying between 50 m and 100 m, and the 10°C isotherm at 150 m in depth. In deeper layers than 200 m, the temperature was less than 4°C as in July and below 300 m a temperature of less than 1°C was found (Fig. 3, E). The salinity of the surface layer was about 17.7-17.9 Cl ‰ (31.9-32.2 ‰) in Maizuru Bay, while about 18.5 Cl ‰ at stations on the Bank. On the Bank the isohaline for 19.0 Cl ‰ was found at 100 m, and that for 18.82 Cl ‰ (34.00 S ‰) between 200 and 400 m, and 18.87 Cl ‰ (34.09 S ‰) at the depth of 400 m near the bottom (Fig. 3, F). At St. 4 it was fairly 18.7-18.9 Cl ‰ (33.7-34.1 S ‰), corresponding with that between 200 m and 400 m on the Bank.

The surface water of Maizuru Bay was oversaturated with oxygen, while the offshore water at all stations was undersaturated from surface to depths (Fig. 4, C). The oxygen content was minimum at the surface and maximum at the depth of 150-200 m layer as in July. The pH value decreased toward the bottom (Fig. 4, D). The phosphate content of the coastal water was only 7 γ /L. In the offshore water on the Bank, it was very poor at the surface, while in the deeper layers, attained about 130 γ /L (Fig. 4, F). The silicate content increased also to lower strata (Fig. 4, I). As shown in Table 1, in the offshore water the value of the catalytic activity was larger than in the coastal water, and it increased toward the deeper layers at each station. The largest value was shown at 5 m depth in Maizuru Bay, at

Table 1. Catalytic activity of sea water—
K_{30°C} · 10³ (September, 25-28, 1950)

Station Depth (m)	2	9	27	31
0	15	17	26	24
5	34	21	—	—
10	22	63	26	25
25		64	87	75
50		59	48	43
100			366	79
150			308	96
200			125	85
250			154	—
300			53	150
350			33	—
400			—	88

25 m depth of Tango Bay, at about 100–150 m depth at St. 27, and about 300 m depth at St. 31.

The water color by FOREL's scale ranged between Nos. 2–7 (Fig. 3, L), and the transparency varied from 4 m to 30 m (Fig. 3, I). The lowest was obtained in Maizuru Bay, and the highest at all stations on the Bank (Fig. 3, I and L).

General Hydrological Conditions

The general hydrological conditions of the Japan Sea have been fully discussed by MARUKAWA & KAMIYA (1926), SUDA et al (1931, 1932 a–b), UDA (1934 a–b, 1936) and MIYAZAKI (1953). As regards the Wakasa Bay and its adjacent areas particularly concerned with this paper, some hydrological observations have already been made in detail by KAMIYA & KUWANA (1925), UDA (1932) and the Maizuru Marine Observatory (1950 a–c, 1952 a–c).

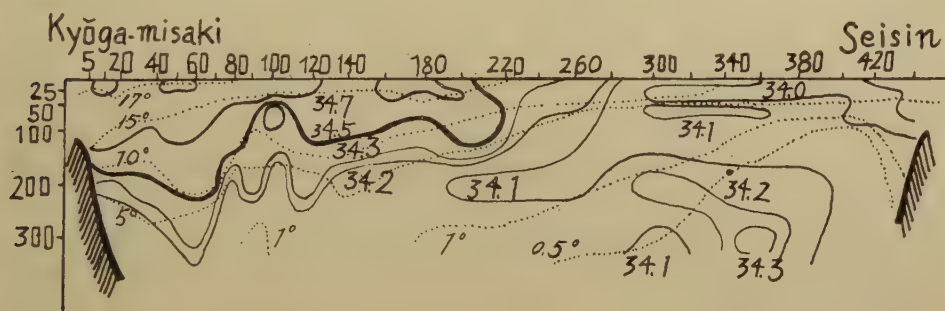


Fig. 5. Water temperature and salinity at section from Kyôga-saki to Sei'sin observed by Kyoto Fish. Inst. on July 5–7, 1932 (after UDA, 1934).

From these previous reports, we recognize that in the seas adjacent to Wakasa Bay, particularly the area off the cape Kyôga-saki, a discontinuity layer lies between depths of about 100 m and 200 m, and that this depends upon the stratification of water masses of different nature. Namely, the warm water-mass of high salinity and temperature belonging to the Tusima Current-system overlies the cold water-mass of low salinity and temperature, which comes from the Liman—North Korea Current-system across the western part of the Japan Sea in a SSE direction. Below the depth of 400 m, the water-mass is almost uniform during all seasons. Our hydrological observations made during three cruises nearly coincide with these previous records.

The New Yamato Bank is a submerged, flat-topped plateau lying below 400 m depth, and thus the Bank itself does not form any obstacle to affect on the water current of this region.

From the planktological point of view, our special interest in the current-system is to know to what extent the disturbance or accumulation of plankton population may take place in consequence of the yearly cycle of hydrological conditions, since the boundary between the cold and warm water-masses fluctuates from month to month, both horizontally and vertically.

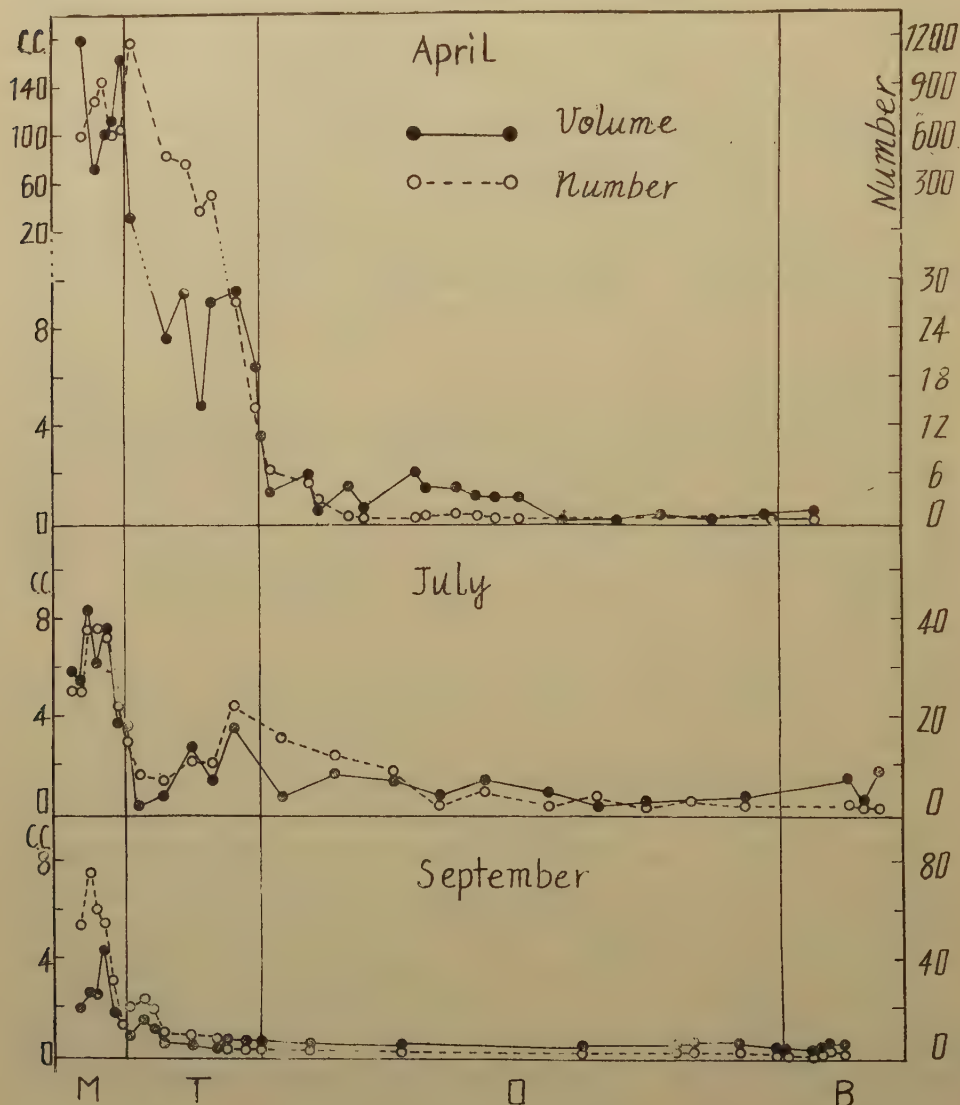


Fig. 6. The relation between the settling volume (cc) of plankton and the number of individuals, cells or colonies (each per 10 minute hauls of superficial layer by the cruise plankton collector) during three cruises from Maizuru Bay to the New Yamato Bank. M=Maizuru Bay, T=Tango Bay, O=Offshore water, B=New Yamato Bank. (These legends at base apply to all forthcoming figures.).

Plankton

A. Quantitative Distribution of Plankton

As is presented graphically in Fig. 6, the relation between the settling volume and total number of individuals, cells or colonies of total plankton caught by the

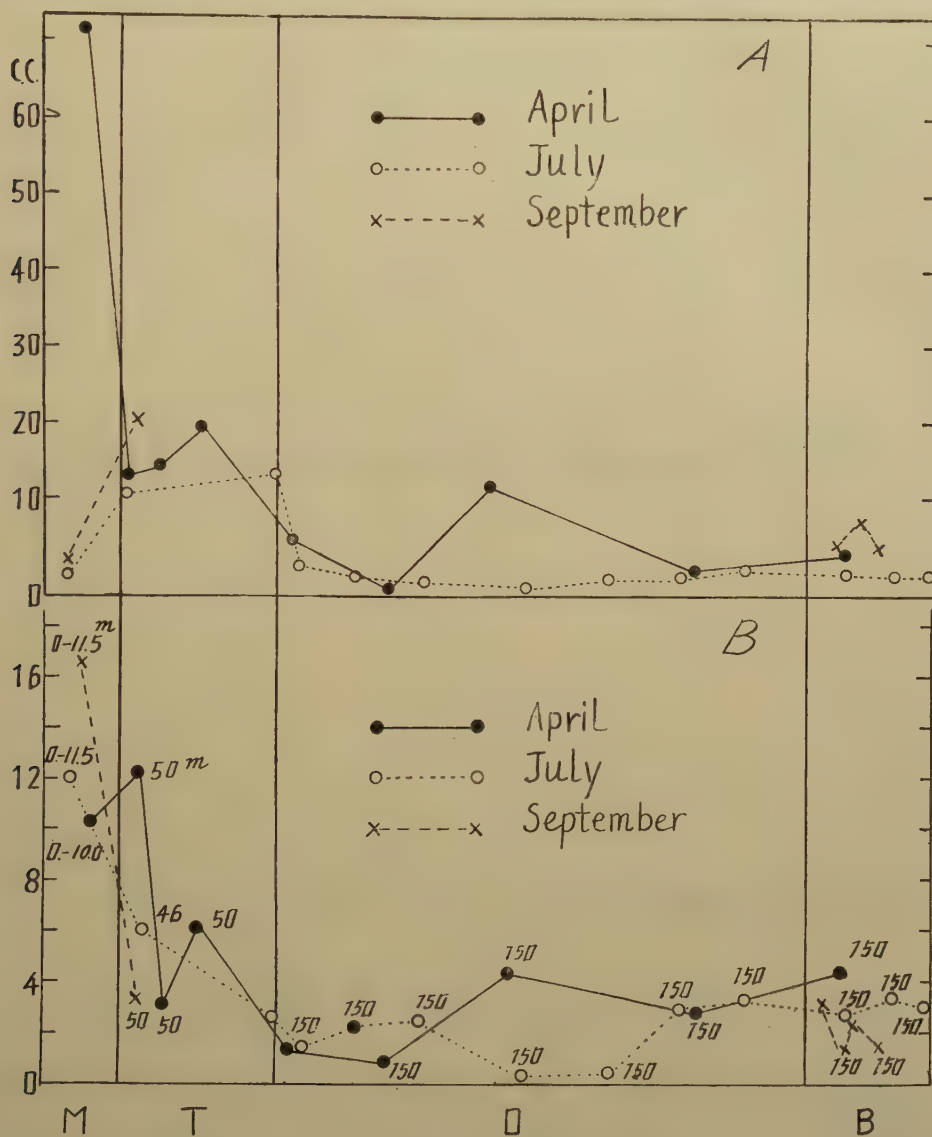


Fig. 7. A, Settling volume of plankton in vertical haul from the surface down to 10-150m depth (each per 10m hauls).

B, Total number of zooplankton in vertical haul from the surface down to 10-150 m depth (numerals indicate the length of haul in 10 meters).

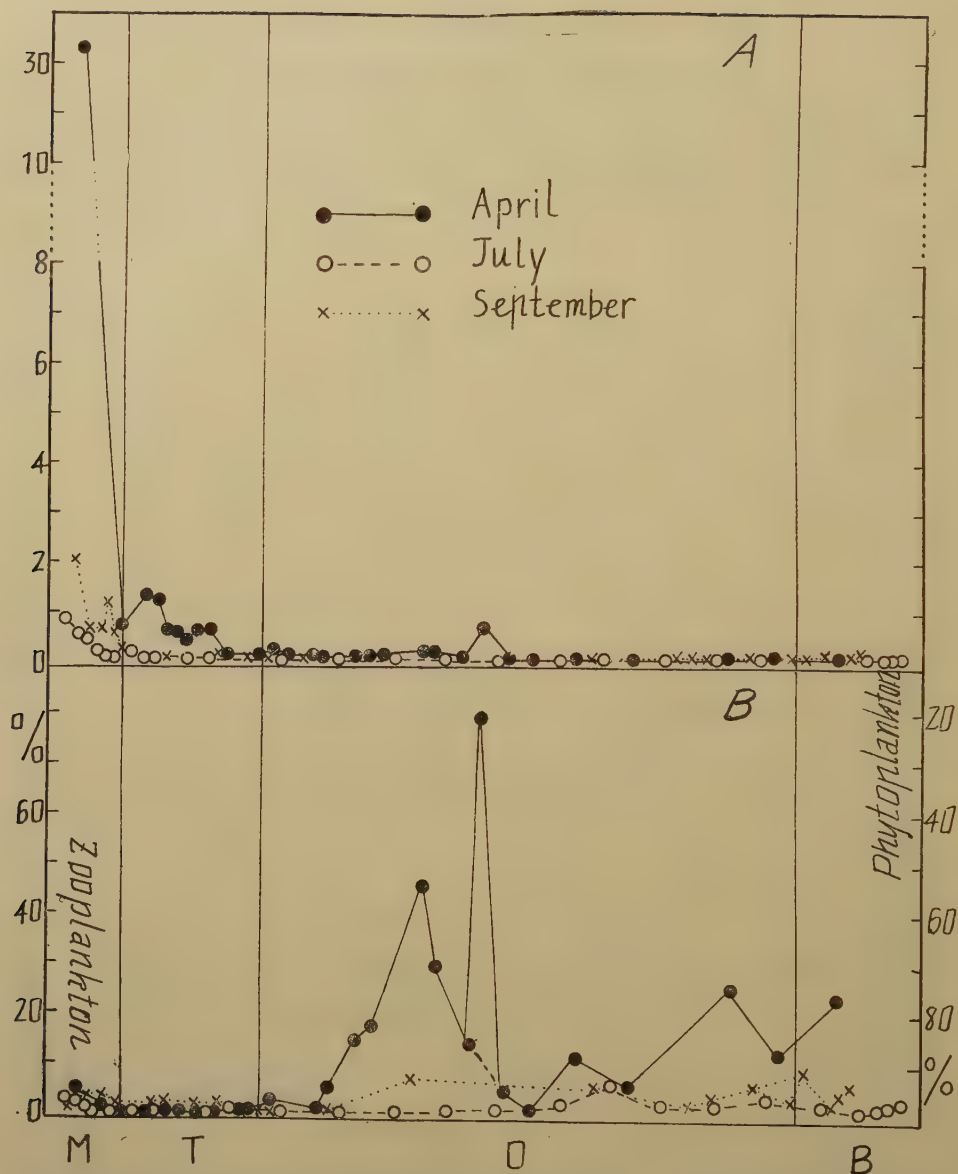


Fig. 8. A, Total number of zooplankton at the stations of superficial haul (each per 10 minutes haul). B, Ratio between zoo- and phytoplankton. Unit of number is thousand.

cruise tow-net from the surface water was almost the same at all stations in the offshore water, in every cruise. The settling volume was very small, less than 2 cc per 10 minutes haul. In the coastal water, however, it is not so close. This is possibly due to the variations in the plankton composition, as will be discussed later. The results obtained from the vertical hauls also present the

similar tendency to the foregoing (Fig. 7).

These data point once again to characteristically the greater richness in the coastal area as compared with the offshore area. Within the coastal area, plankton were always the most abundant in Maizuru Bay and intermediate in the coastal area of Tango Bay and near Kyôga-saki. Furthermore, these figures clearly indicate the existence of a seasonal variation in richness in the coastal area. Although our present data unfortunately lack the record during the cold period, the hauls of smallest volume occurred in September and largest in April. According to the serial observation off Kyôga-saki made by the Maizuru Marine Observatory in winter, the plankton as a whole here reached its smallest during winter, the average volume being 1.03–1.71 cc/m³ during winter and 5–10 cc/m³ during summer. However, the volume greatly increased to about 50 cc/m³ in March only when spring diatom flowerings occur (Maizuru Jour. Ocean., vol. 1, no. 3/4, p. 4, 1952).

When the phyto- and zooplankton were treated separately, the numerical

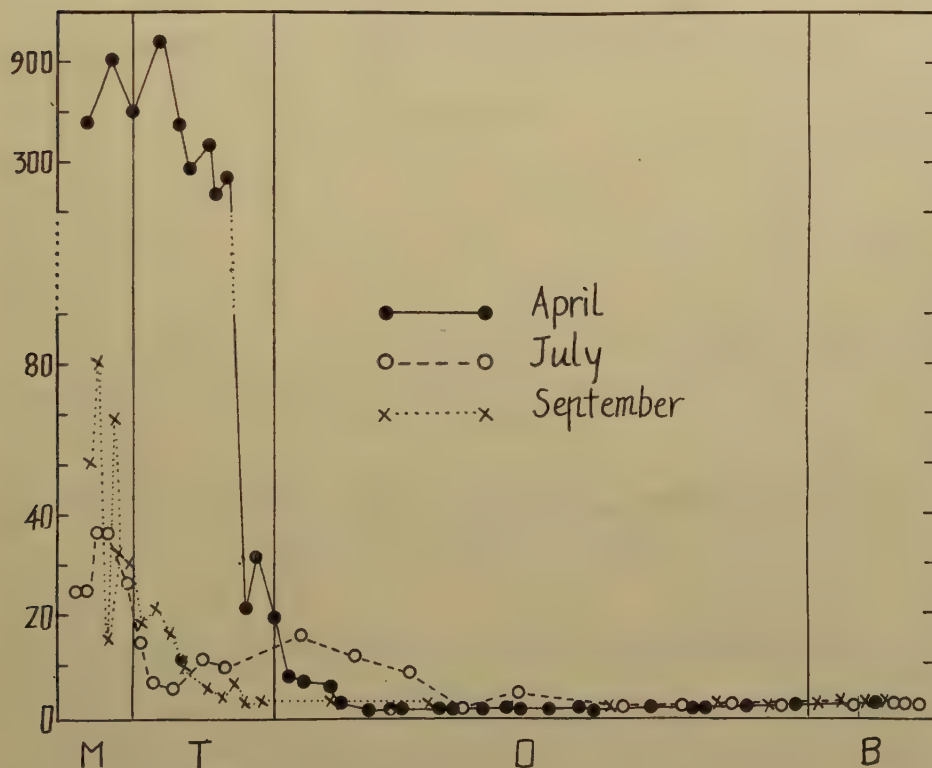


Fig. 9. Total number of phytoplankton at the stations of superficial haul (each per 10 minutes haul). Unit of number is thousand.

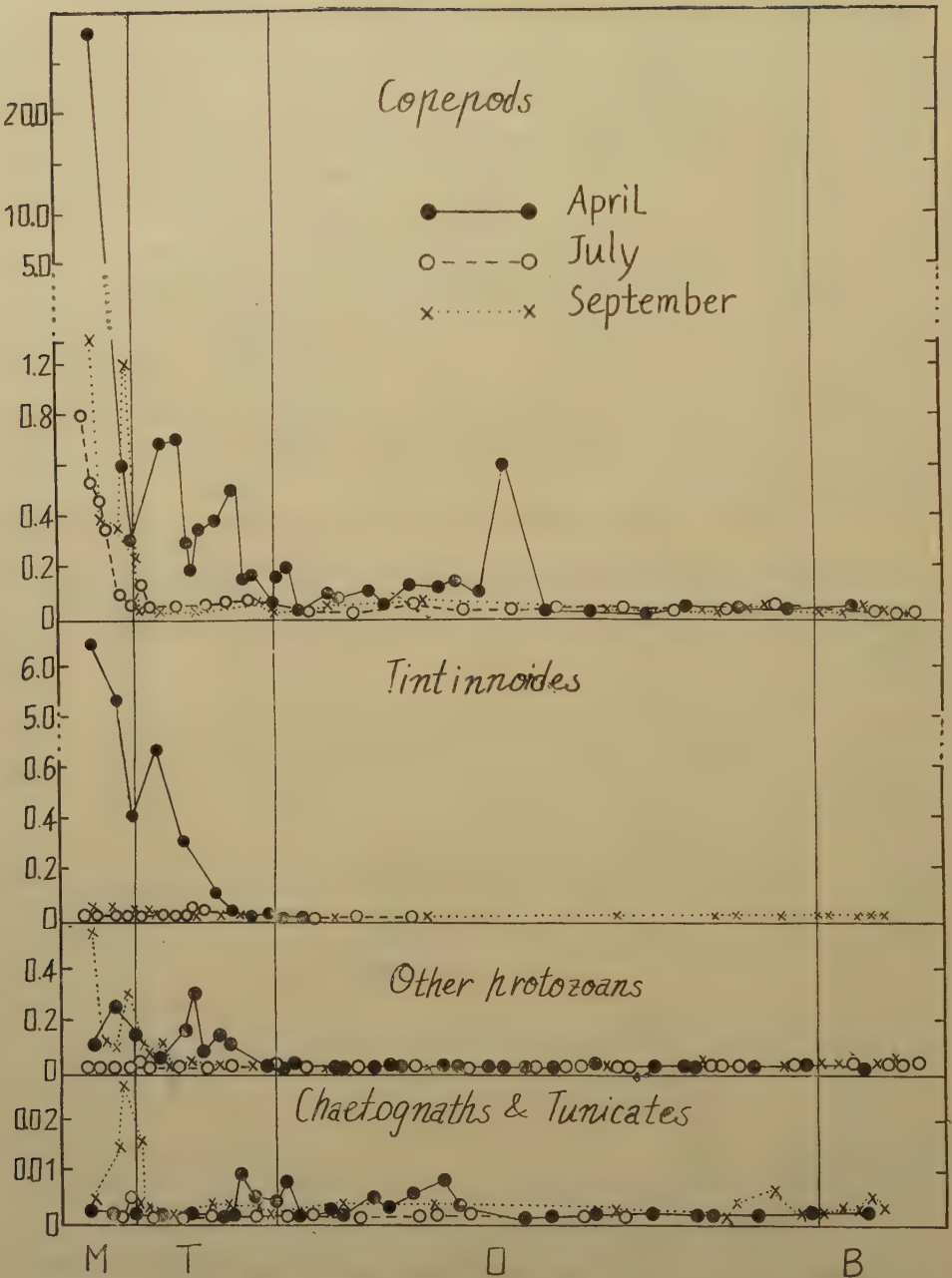


Fig. 10. Individual number of important groups of zooplanktons at the station of superficial haul (each per 10 minutes haul). Unit of number is thousand.

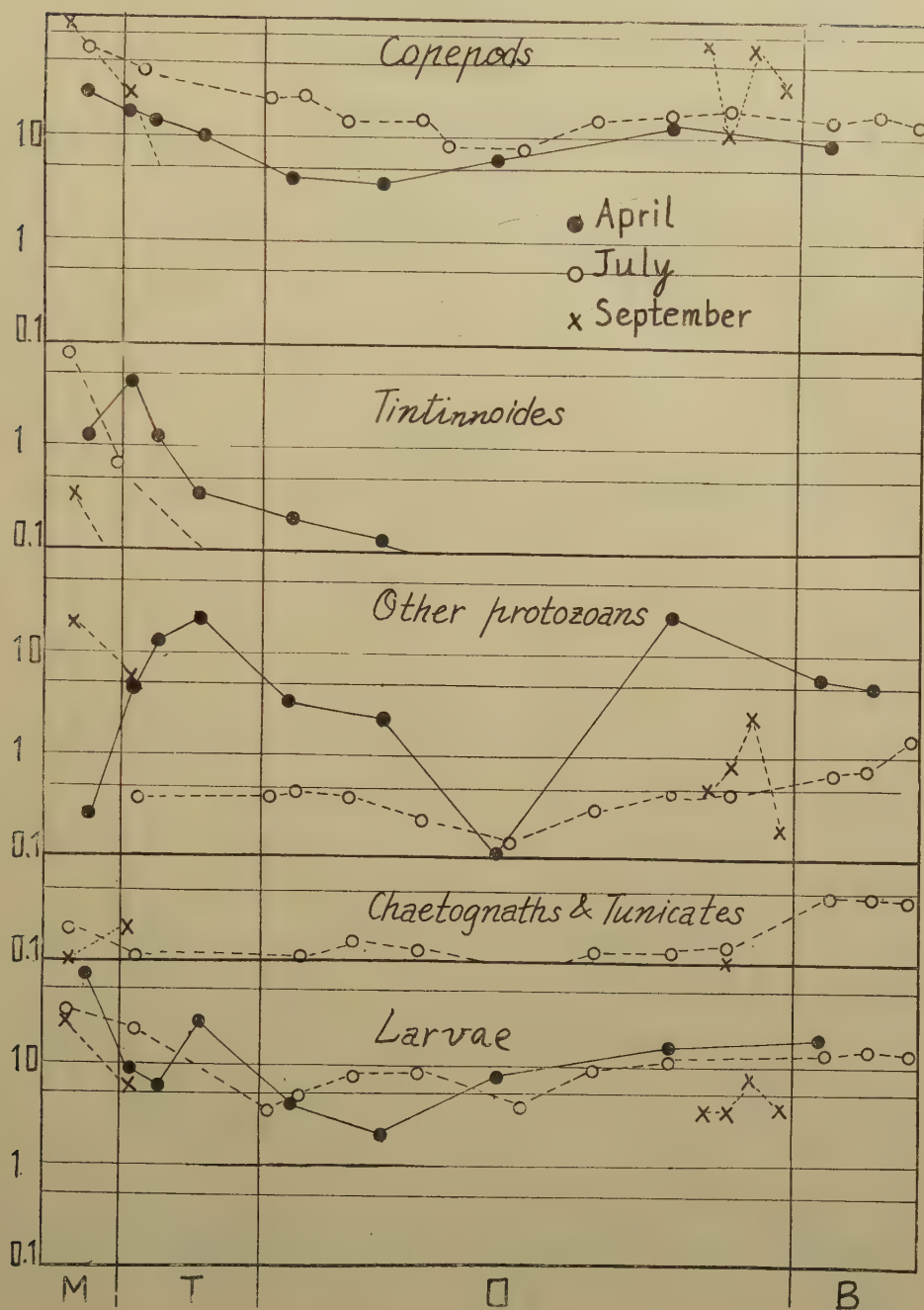


Fig. 11. Individual number of important groups of zooplankton at the stations of the vertical haul. Unit of number is thousand.

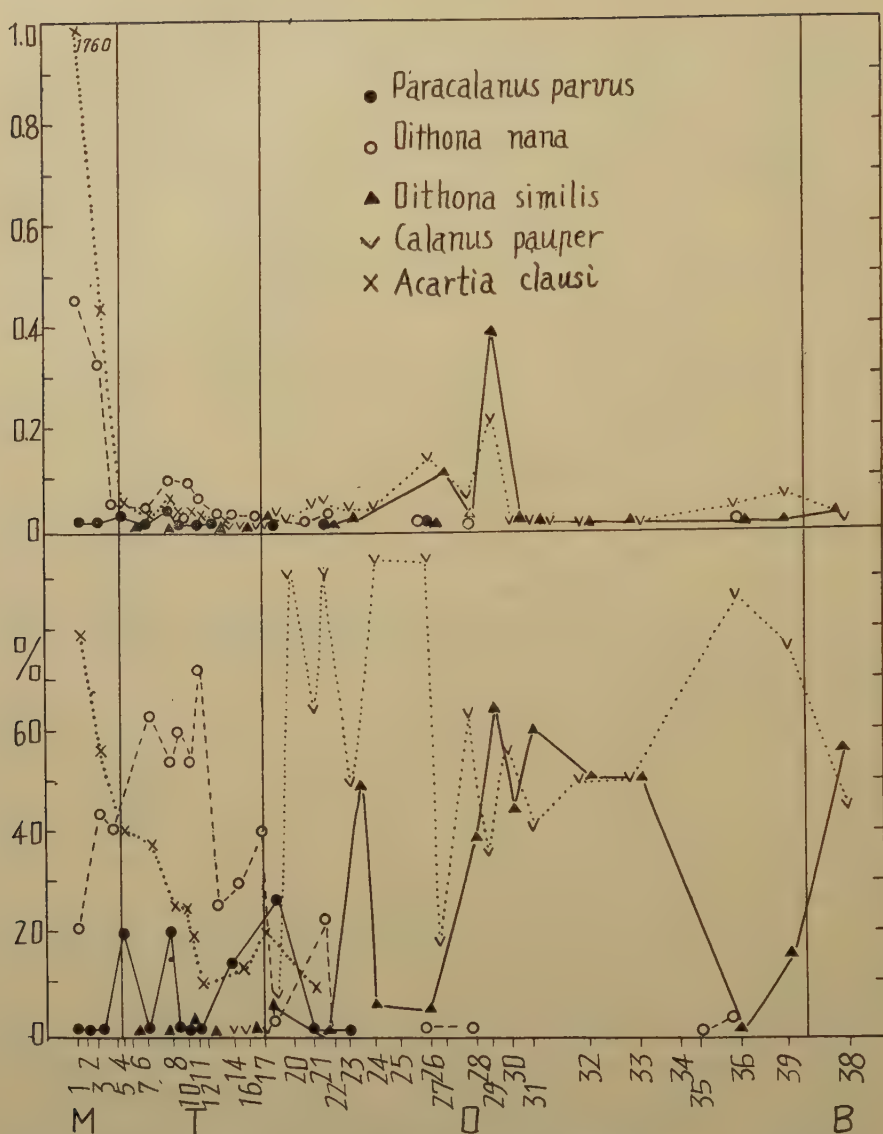


Fig. 12. Number of important copepods per 10 minutes superficial haul (above), and percentage composition (below) on April, 27-28, 1950. Unit of number is thousand.

percentage of zooplankton in the total plankton ($Z/N \times 100$) was very small as a whole, except for the offshore area in April, where it reached 80 % (St. 29), and in the coastal area less than 5 % in every cruise (Fig. 8, below). The population of phytoplankton (Fig. 9) was very rich in the coastal water, particularly in April, as compared with that of zooplankton (Fig. 8, above). However, it decreased abruptly in July and further in September, as described also by AIKAWA (1936 b, p. 105).

B. Qualitative Distribution of Plankton

Zooplankton

The main part of zooplankton was occupied by copepods and followed by other components of small quantity, such as tintinnoids, cladocerans, hydromedusae, chaetognaths and the larval forms (Figs. 10, 11). Among the important copepods, *Oithona nana*, *Acartia clausi*, *Paracalanus parvus* and their nauplii were generally rich in the coastal area. Other calanoids, *Oithona similis*, *Oithona plumifera*, *Oncaea candacia*, etc. were found mainly in the offshore water off

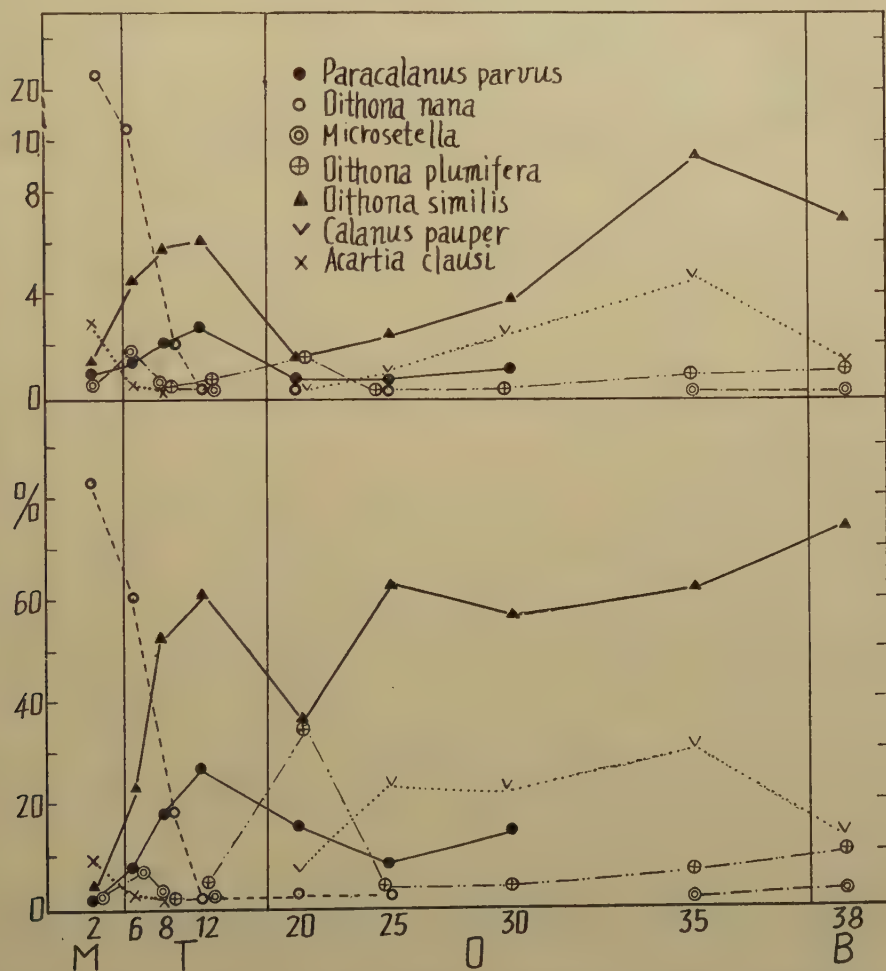


Fig. 13. Number of the most important copepods per 10 m vertical haul from the surface to 10-350 m depth (above) and percentage composition (below) on April 26-28, 1950. Unit of number is thousand.

Kyôga-saki, though not so abundant as in the foregoing (Figs. 12-17). Of these copepods, *Acartia clausi*, which is an indicator species of inlet or bay water, was found by far abundantly in April in Maizuru Bay, decreasing abruptly outwards. *Oithona nana*, which is more euryhaline than *Acartia clausi*, came next in that Bay and Tango Bay, although widely spreading far out of the Bay

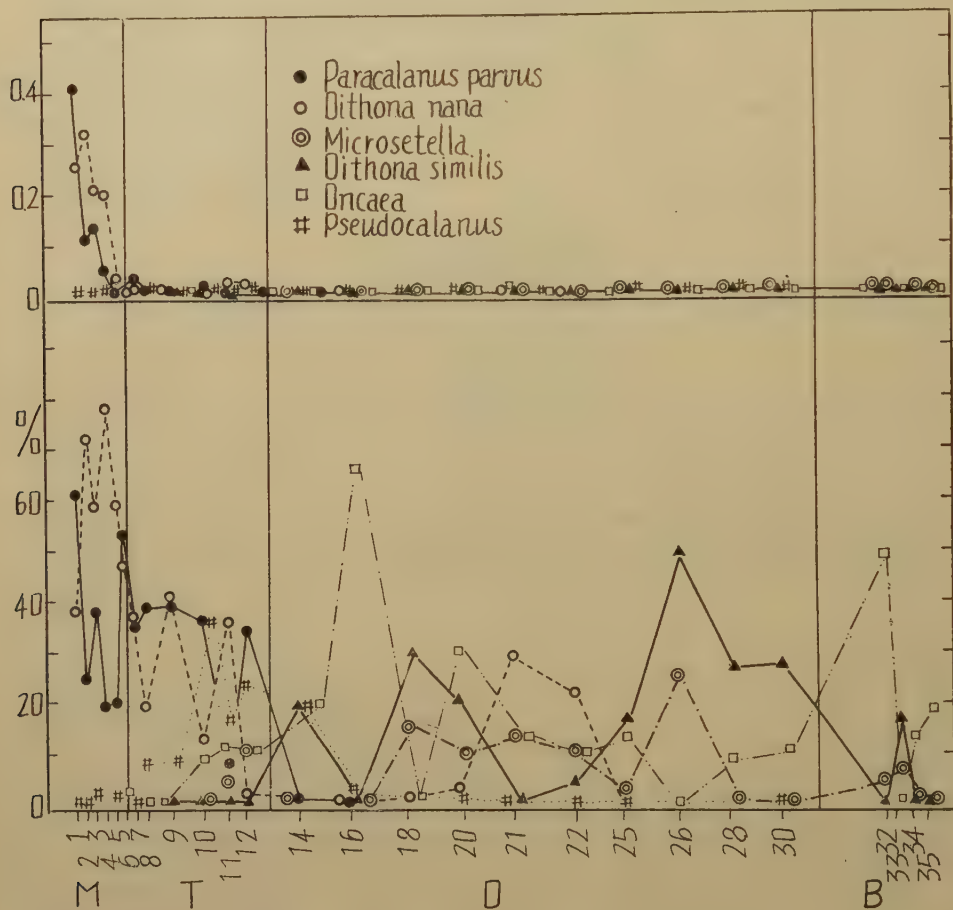


Fig. 14. Number of the most important copepods per 10 minutes superficial haul (above), and percentage composition (below) on July 24-26, 1950. Unit of number is thousand.

sparsely. *Paracalanus parvus* was uniformly distributed in wider areas, but its center of abundance was found to be located within the inner portion of Tango Bay. *Oithona similis*, which occurred widely in Tango Bay and further offshore water, was found during all cruises, and richest in July. *Oithona plumifera* was also observed in every cruise in the same area. The other warm water forms

which were scarce but important for the offshore water, are: *Calanus helgolandicus*, *Cal. minor*, *Cal. darwinii*, *Eucal. mucronatus*, *Mecynocera clausi*, *Euchaeta flava*, *Euchaeta plana*, *Euchaeta ovata*, *Tortanus forcipatus*, *Candacia bipunctata*, *Oithona plumifera* and *Microsetella rosea*. These species were greater in abundance in July and September than in April.

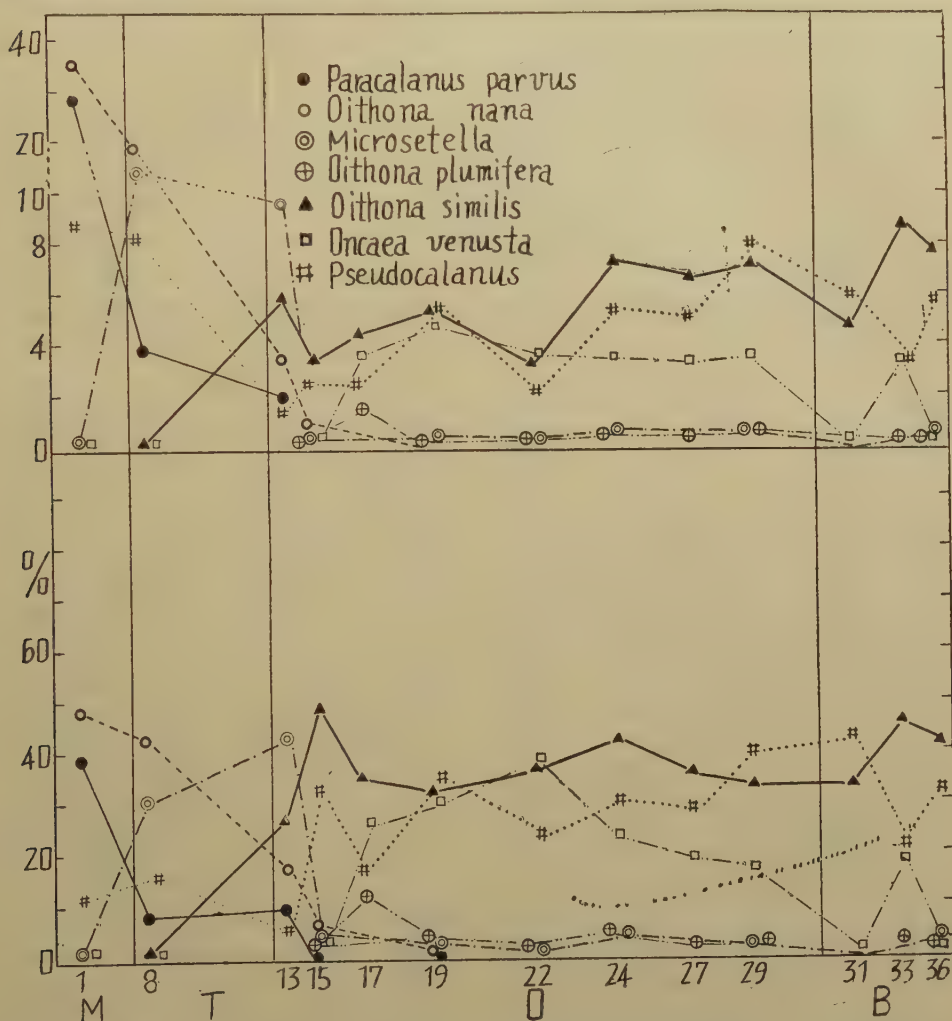


Fig. 15. Number of the most important copepods in the vertical haul from the 10-150 m depth to the surface. Unit of number is thousand, and all hauls combine together for each station (above) and percentage composition (below) on July 24-26, 1950.

The other warm water copepods observed in the offshore waters, though scarce, are as follows:

Oncaea media, *Corycaeus longicruris*, *Cory. crassiusculus*, *Copilia mirabilis*, *Copilia longistylis*, etc. July and September.

Cal. tenuicornis, *Cal. pauper*, *Cal. robustior*, *Eucal. attenuatus*, *Acartia negligens*, etc. April and July.

Cal. vulgaris, *Tortanus forcipatus*, etc. April only.

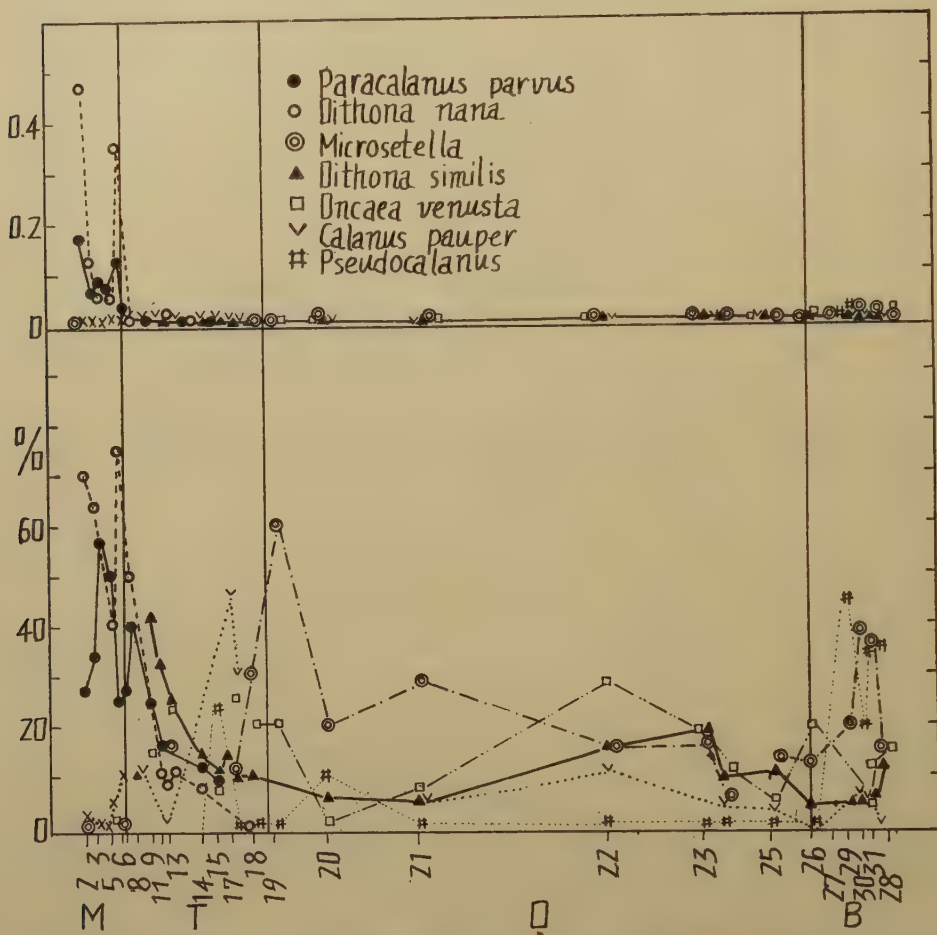


Fig. 16. Number of the most important copepods in the surface haul (above) and percentage composition (below) on September 25-27, 1950.

Besides, it is noticeable to find some cold water forms in deeper strata throughout the year, although not so common as the warm water forms. The representative copepods are: *Calanus cristatus*, *Cal. plumchrus*, *Eucalanus giesbrechti*, *Pseudocalanus elongatus*, *Pseudocalanus minutus*, *Metridia lucens*.

Evadne nordmanni, *Evadne tergestina*, *Podon leuckarti* and *Penilia schmackeri* are the important cladocerans appeared throughout the period. Other

crustaceans, such as *Conchoecia* sp., *Euphausia* sp., *Lucifer raynaudii*, *Vibilia viator*, *Clytomnestra scutellata*, etc. were sporadically found. Most of the chaetognaths, such as *Sagitta enflata*, *S. bedoti*, *S. regularis* and *S. minima* which appeared rather abundantly in the surface hauls, are the warm water species, while *Sagitta elegans* found in the deep layer only belongs to the cold water form. Among pelagic tunicates, such species as *Oikopleura longicauda*, *O. fusiformis*, *O. rufescens*, *Fritillaria*, *haplostoma*, *F. formica*, *F. pellucida*, *F. borealis*, *F. tenella*, etc. were frequent in offshore waters, during the cruises of July and September (TOKIOKA, 1951). *Doliolum nationalis*, a pteropod *Creseis acicula* and several species of hydromedusae were also frequent. Among tintinnoids, *Tintinnopsis beroidea*, *Tint. radix*, *Tin. aperta*, *Favella taraikaensis*, and *Favella* sp. were frequent in the coastal water in April and July. *Favella campanula* was found in September, while *Tintinnus lusus-undae* in July and September.

Acanthometron pellucidum, radiolarians, and *Globigerina bulloides* were also important components of protozoans, appearing in wide areas. *Noctiluca scintillans* and *Dictyocha fibula* were found only inside the bay.

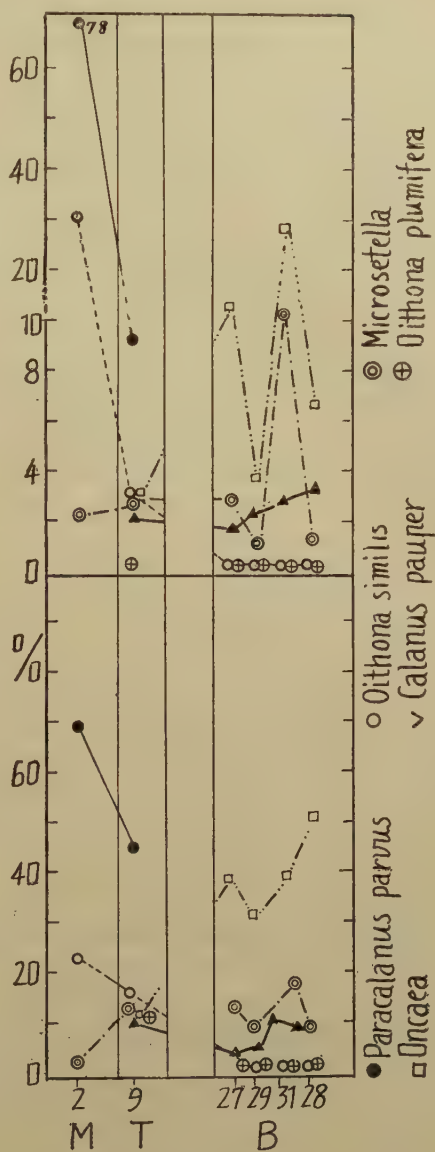


Fig. 17. Number of the most important copepods in the vertical haul (above) and percentage composition (below) on September 25-27, 1950.

Phytoplankton

During all cruises, diatoms dominate the planktonic community everywhere, though quantitatively varied (Figs. 8, B & 9).

Phytoplankton in April: The seasonal variation concerned with the present survey is graphically indicated in Fig. 18. According to Mr. FURUHASHI's observations in Maizuru and Tango Bay, the spring flowering of diatoms begins generally late in January and continues to the end of March. The leading diatoms showing spring flowering are *Chaetoceros* and *Rhizosolenia*. The other diatoms are very small in numerical abundance. The dinoflagellates were represented by 15 species of *Ceratium*, *Peridinium*, *Goniaulax*, *Dinophysis* and *Pyrophacus*, though relatively small in quantity. *Chaetoceros danicus* and *Ch. affinis* were by far predominant in the coastal area, but gradually decreased in number outside. *Ch. compressus*, *Ch. laciniosus*, *Ch. didymus*, *Ch. brevis*, *Ch. curvisetus*, *Ch. coarctatus* and *Ch. peruvianus* in the oceanic area come next. *Rhizosoleniae* were represented by large numbers of *Rh. setigera* and *Rh. hebetata* forma *semispina* and small number of *Rh. stolterfothii*, *Rh. alata* forma *indica*, *Rh. alata* forma *gracillima*, *Rh. imbricata*, *Stephanopyxis palmeriana*, *Skeletonema costatum*, *Leptocylindrus danicus*, *Hemiaulus sinensis* and *Thalassiothrix Frauenfeldii* were also present, though only in very small numbers.

Phytoplankton in July: The major components were almost similar to those found in April, although varied in abundance and distribution. The populations of *Chaetoceros* in the coastal area showed a marked decrease. Important components were species of *Chaetoceros* and *Rhizosolenia* as well. Among them, *Ch. affinis*, *Ch. laciniosus*, *Ch. van Heurckii*, *Ch. compressus*, *Ch. Lorenzianus*, *Ch. decipiens*, *Ch. pelagicus*, *Ch. peruvianus*, *Rh. hebetata* f. *semispina* and *Rh. alata* f. *gracillima* were found most abundantly. *Bacteriastrum hyalinum*, *Climacodium Frauenfeldianum*, *Cerataulina Bergonii*, *Hemiaulus Hauckii*, *H. sinensis*, *Thalassionema nitzschioides*, *Thalassiothrix Frauenfeldii*, *Th. longissima* and *Nitzschia seriata* were also found.

Dinoflagellates, on the contrary, showed a marked increase and about 30 species were found at all stations in the coastal area. *Ceratium extensum*, *Cer. carriense* and *Cer. macroceros* were found most abundantly off Kyôga-saki. *Pyrophacus horologicum*, *Peridinium grande*, *Cer. tripos*, *Cer. macroceros* and *Cer. massiliense* were widely distributed. *Per. oceanicum* var. *oblongum*, *Per. depressum*, *Cer. fusus* var. *strica* and *Cer. inflexum* were restricted only to the inlet or bay waters of the coastal area.

Phytoplankton in September: The phytoplankton were dominated by diatom and dinoflagellates as well. The leading species of diatoms are *Chaetoceros* spp. and *Rhizosolenia* spp. and *Bacteriastrum hyalinum*, *Ditylum Brightwellii*,

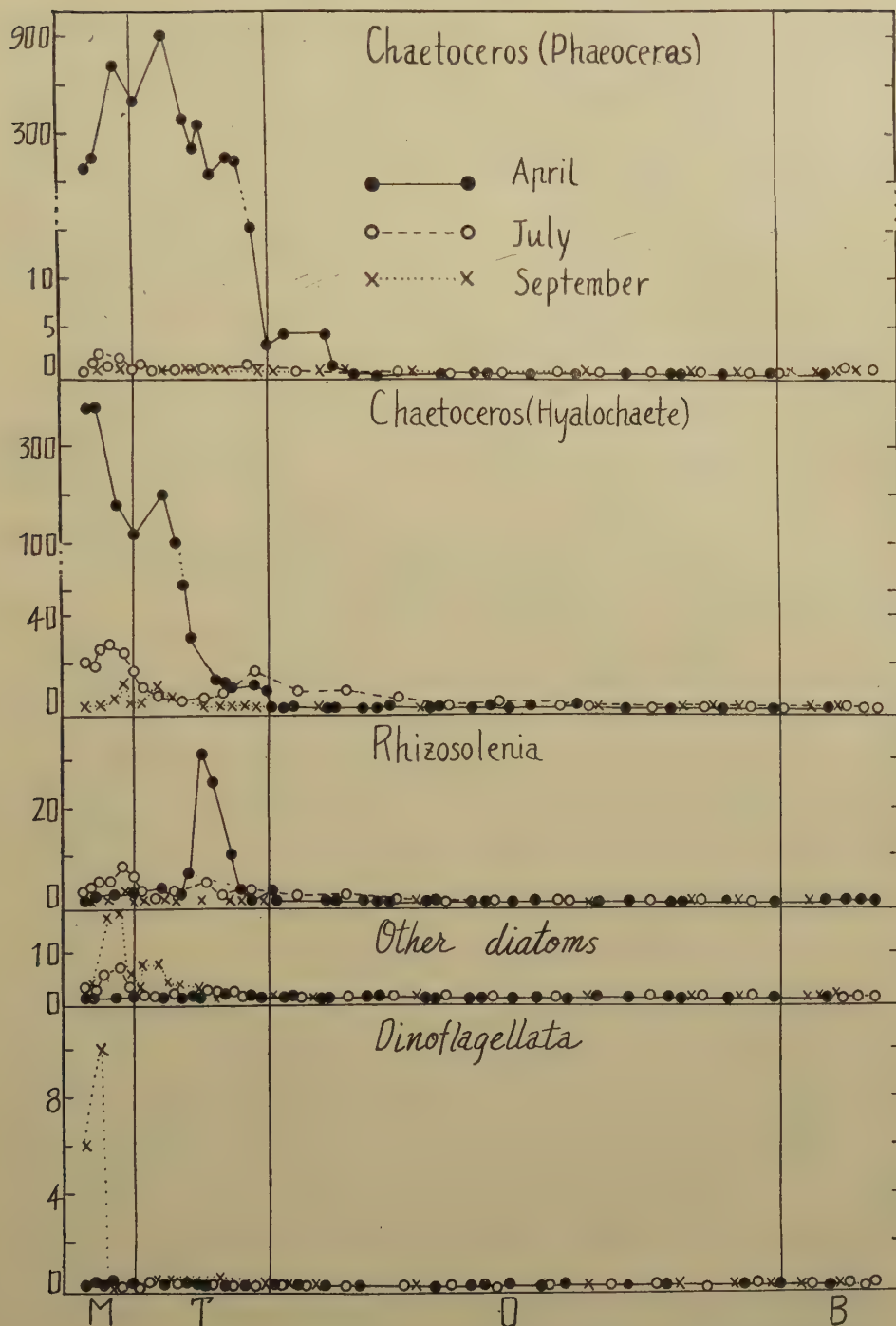


Fig. 18. Number of important groups of phytoplankton at the stations during these cruises.

Dactyliosolen mediterraneus, *Dac. antarcticus*, *Thalassionema nitzschioides*, *Thalassiothrix Frauenfeldii* and *Nitzschia seriata*. Among *Chaetoceros*, *Ch. laciniosus*, *Ch. curvisetus*, *Ch. van Heurckii*, *Ch. compressus*, *Ch. didymus* and *Ch. Lorenzianus* were quite numerous in Maizuru and Tango Bay. *Ch. coarctatus*, *Ch. tetrastichon*, *Ch. dadayi* and *Ch. convolutus* were found in the offshore water, but they were very sparse. *Rhizosolenia setigera*, *Rh. hebetata* f. *semispina*, *Rh. calcar-avis*, *Rh. alata* f. *gracillima*, *Rh. alata* f. *indica* were evenly distributed there, and *Rh. cylindrus*, *Rh. Bergonii*, *Rh. stoltzerfithii*, *Rh. styliformis* and *Rh. acuminata* occurred in Tango Bay and further off the coast.

Dinoflagellates were as abundant as in July, and represented by about 40 species during this period. Among them, *Ceratium furca* was the most prominent. Its distribution was restricted to the coastal water, abundantly in Maizuru Bay, and sparsely in Tango Bay. *Dinophysis caudata*, *Pyrocystis noctiluca*, *Pyr. lunula*, *Ceratocorys horrida*, *Pyrophacus horologicum*, *Amphysolenia bidentata*, *Peridinium grande*, *Ceratium fusus*, *Cer. extensum*, *Cer. Kofoidii*, *Cer. gibberum* f. *sinistrum*, *Cer. tripos*, *Cer. pulchellum*, *Cer. trichoceros*, *Cer. inflexum*, *Cer. intermedium* and *Cer. massiliense* were widely distributed.

Generally speaking, the inshore area such as Maizuru Bay and Tango Bay was dominated by the neritic phytoplankton, mostly belonging to *Chaetoceros*. Other diatoms and dinoflagellates were comparatively few in number. The phytoplankton in the offshore water off Kyôga-saki were markedly poor as compared with Tango Bay. In offshore water, neritic diatoms were also found scarcely. In Tango Bay where phytoplankton were numerically greatest, some offshore forms were found in the central portion and formed a mixed population with the neritic forms which are richer than the former.

C. Number of Species

From the number of species appeared in the superficial haul at every station as shown in Fig. 19, seasonal changes of the plankton composition may be recognized. Upon comparing the successive changes at each station, it will be noticed that phytoplankton were more abundant than zooplankton in quantity during every cruise and that the largest number was obtained in September and the smallest in April. With reference to the regional distribution, the phytoplankton on the whole was the richest in Tango Bay and poorest in Maizuru Bay.

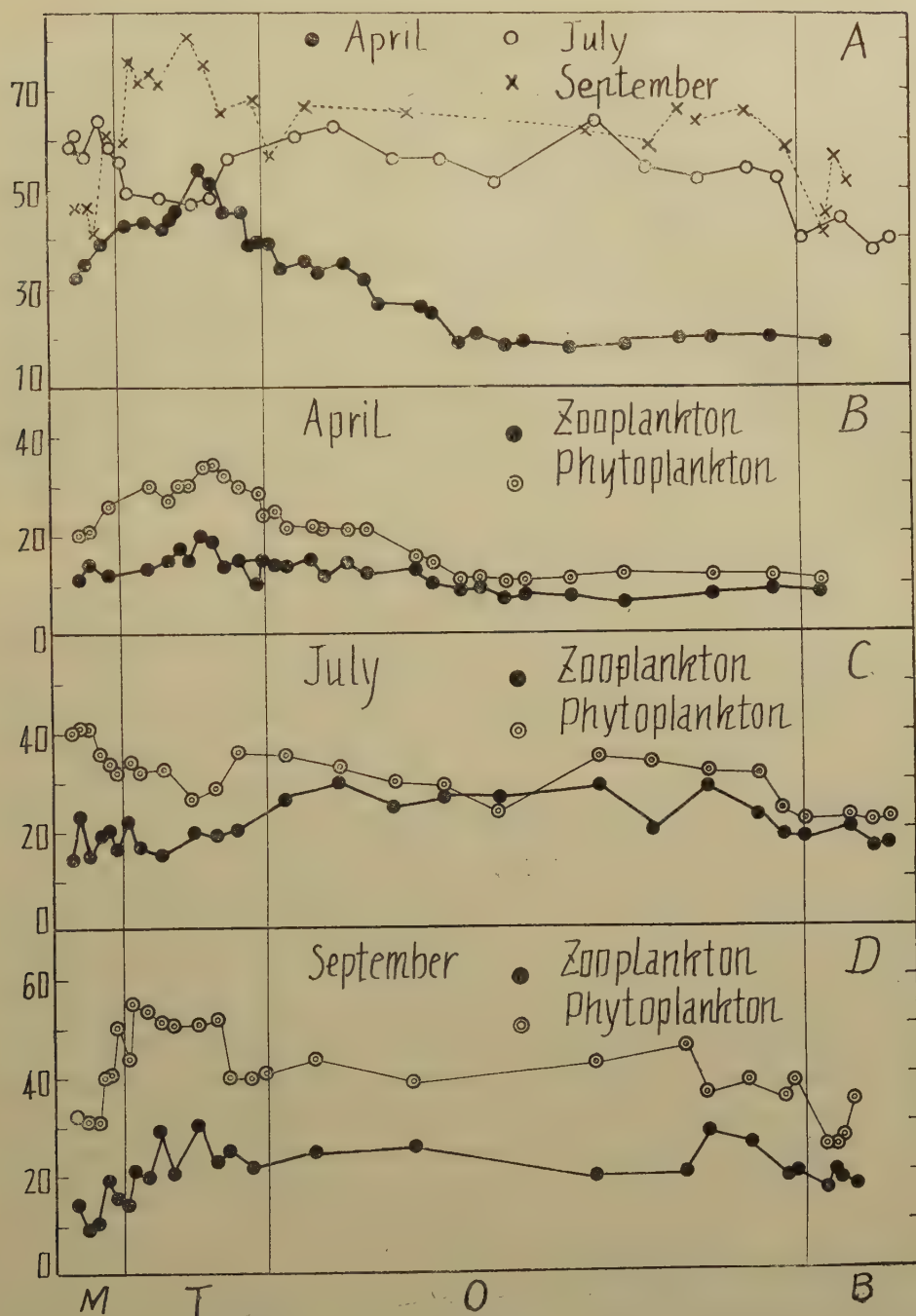


Fig. 19. Number of species in the superficial haul. A, Total number of species during cruises of April, July and September. B, Number of species of zoo- and phytoplankton, on April 26-28, 1950. C, Number of species of zoo- and phytoplankton, on July 24-26, 1950. D, Number of species of zoo- and phytoplankton on September 25-27, 1950.

Discussion

A. Properties of Offshore Plankton

The plankton community occurring in the southern part of the Japan Sea, is influenced by both the cold and warm currents, the Liman—North Korea Current flowing from north and the Kuroshio—Tusima Current flowing into the Japan Sea from the Korea Strait. The planktological investigations in this region have been made mainly by MARUKAWA (1928), KURASIGE (1932 a, b), YAMADA (1933 a, b, 1936), AIKAWA (1930, 1934, 1936 a, b) and TOKIOKA (1940). First of them, MARUKAWA (1928) considered that the plankton of the region consists of two elements, (1) the native species such as *Calanus plumchrus*, *Oithona similis*, *Paracalanus parvus*, *Pseudocalanus elongatus*, etc., which are found everywhere and every season, and (2) the exotic species, such as *Halosphaera viridis*, *Trichodesmium Thiebautii*, *Sticholonche zanclea*, etc. which are found only in the area influenced by the warm Tusima Current.

The admixture in various proportions of both the cold and warm water forms is seen in the area adjacent to Uturyô-tô (Dageret Island) to some extent (KURASIGE, 1932 a, b; YAMADA, 1933 a, b; TOKIOKA, 1940). According to these authors, the main component of plankton found in the mixed area consists of three sources; the warm water species* introduced from the Yellow Sea and the coastal water of southern Korea through the Korea Strait, such as *Sagitta crassa*, *Parathemisto* sp., *Euchaeta marina*, *Acartia clausi*, etc. (2) from the Kuroshio Current or the coastal water along Kyûsyû, through the Eastern Strait of Tusima, such as *Sagitta bedoti*, *S. enflata*, *Doliolum nationalis*, *Salpa fusiformis*, *Rhincalanus cornutus*, *Candacia bipinnata*, *Calanus mucronatus*, *Creseis acicula*, etc., and (3) the cold water species, which are prevalent around the northeastern area of Korea, such as *Ceratium bucephalum*, *C. arcticum*, *C. longipes*, *Pseudocalanus elongatus*, *P. magna*, *Calanus cristatus*, *Cal. plumchrus*, *Metridia lucens*, *Sagitta elegans*, etc. AIKAWA (1936) pointed out that the warm water forms brought into the Japan Sea through the Tusima Current are mostly of the proper Kuroshio group and that the cold water forms of the Liman group in the southern Japan Sea are only driven northwards when the influence of Kuroshio Current becomes more vigorous, although reaching as far south as Uturyô-tô in winter to spring.

From the planktological point of view, our interest in the current system of the Japan Sea lies in the fate of the Liman—North Korea Cold Current,

* For convenience sake, the species of diatoms are omitted in consideration herein.

and in the extent to which the cold water forms proper to the said cold current can approach the Japanese coast in the southern part. Some cold water forms (*Calanus plumchrus*, *Pseudocalanus elongatus*, *Pseudolovenula magna* and *Parathemisto obliqua*) were found formerly by KURASIGE (1932 a) in small quantities in the southern Japan Sea more southwards than Uturyô-tô, but he gave no much stress on their southward extension of range. It was recently revealed by TOKIOKA (1951) and FURUHASHI (1952 a, b, 1953) too, since several cold water forms were found in the deeper layers off Kasumi and off Kyôgasaki throughout the year, although in a few number for each haul. During our cruises, this fact has been confirmed by vertical hauls. In the offshore water of the region referred to, most of the warm water forms were found in superficial layer shallower than 100 or 150 m and the cold water forms were exclusively in deeper layers, showing a nearly stratified distribution.

1. Warm water plankton community in upper layers

Most of the plankton appeared from about 100 m to the surface off Kyôgasaki were the warm water species. These forms are chiefly of the Kuroshio Current origin, such as *Oithona plumifera*, *Oncaea venusta*, *Calanus darwinii*, *Cal. tenuicornis*, *Cal. helgolandicus*, *Cal. robustior*, *Eucal. attenuatus*, *Mecynocera clausi*, *Euchaeta*, *Saphirina*, *Sagitta enflata*, etc. Among oceanic diatoms and dinoflagellates, *Ch. coarctatus*, *Ch. denticulatus*, *Ch. atlanticus* var. *neapolitana*, *Ch. tetrastichon*, *Ch. dadayi*, *Rhizosolenia* spp., *Ceratium gibberum*, *C. platycornu*, *C. tripos*, *C. smatoranum* and *C. candelabrum* were dominant. The presence of neritic species, such as *Sagitta crassa* f. *typica*, *S. crassa* f. *naikaiensis*, *Oikopleura dioica*, *Parathemisto* sp., pelecypod and gastropod veliger, *Tornaria*, *Ophiopluteus*, *Skeletonema*, *Stephanopyxis*, *Nitzschia seriata*, etc. occurring chiefly in the Yellow Sea, the Korea Strait and the western coast of Kyûsyû were also noticeable. It is clear from these records that the water in the upper layer is occupied by the warm water-mass of the Tusima Current which was influenced several times in the course by the inshore waters along the coasts of Kyûsyû, southern Korea and San'in district.

2. Cold water plankton community in deeper layers

Adjacent to the island Uturyô-tô and near the area on the Yamato Bank (KURASIGE, 1932 a, b), the cold water species are found in the surface layer in summer. During the present cruises any cold water species were not found in the surface. But some cold water species, which were probably originated

Table 2. Vertical distribution of the cold water species found during three cruises.

Date of cruise		April 26-28, 1950					July 24-26, 1950					September 25-28, 1950						
		30	35	38	24	27	29	31	33	36	27	28	29	31				
Station		50	150	50	150	150	150	400	400	150	300	150	350	350	150	350	350	350
Hauled distance (m)		-0	-0	-0	-0	-0	-0	-200	-200	-0	-150	-0	-150	-150	-0	-0	-0	-0
<i>Calanus cristatus</i>		2	2	3	16			2	1						1	2	1	7
<i>Calanus plumchrus</i>																1		
<i>Eucalanus giesbrechti</i>																		
<i>Metridia lucens</i>																		
<i>Vibilia viator</i>				1	4			1	10	1	1	1	2					10
<i>Aglantha digitale</i>																		
<i>Sagitta elegans</i>		2	1							1		1	1	2				
<i>Oikopleura labradoriensis</i> ..			1	1	1											3	4	2
<i>Limacina helicina</i>		3	18	5	4	5												

from the Liman—North Korea Current, were obtained below 100 or 150 m depth (Table 2). All of them belong to the zooplankton, and any phytoplankton were not encountered. They are:

Crustacea—*Calanus cristatus*,
Cal. plumchrus, *Eucal. giesbrechti*, *Metridia lucens* and
Vibilia viator.

Medusae—*Aglantha digitale*.

Chaetognatha—*Sagitta elegans*.

Tunicata—*Oikopleura labradoriensis*.

Mollusca—*Limacina helicina*.

Besides, FURUHASHI (1952 b) found some cold water plankton animals in samples hauled from the deeper layer during the period from May to August 20-30 miles off San'in district. He also found a large number of the cold water species in the surface haul (0-50 m) from winter to early spring within 1-20 miles off Kyôga-saki, although the warm water species were predominant (Maizuru Mar. Obs., 1952 b). Representatives recorded by FURUHASHI in both reports, besides the above-mentioned species, are as follows: Copepods—*Pseudocalanus minutus*, *Ps. elongatus*, *Ctenocalanus longicornis*, *Ct. vonus*, *Corycaeus japonicus*, *Euchaeta japonica*; Pteropods—*Clione limacina*. Most of them are prevalent in the northern part of the Japan Sea (AIKAWA, 1936 a, b; MOTODA, IIZUKA and ANRAKU, 1950).

On the basis of vertical distribution of general oceanographical factors, UDA (1934 a, b, 1936) distinguished three water layers in the Japan Sea. Namely, (1) the Yellow Sea water with low salinity enters into the Japan Sea from the western side (Korean side) of Tusima Strait and spreads on the surface layer (surface to 20 or 30 m) in wide area of the southern Japan Sea in summer, (2) the warm water of the Tusima Current with high temperature, high salinity, poor nitrates, poor silicates and poorly dissolved oxygen forms the intermediate layer (from 25 m to 200 m depth), and (3) in the deeper layer below about 200 m cold water-mass with low temperature, comparatively low salinity, rich nutrients and richly dissolved oxygen. He (1934 b, p. 99) also commented that the North Korea Cold Current with richly dissolved oxygen and low salinity seems to descend obliquely under the warm water-masses of Tusima Current in the southern part of Japan Sea east of Korea (Fig. 5). From the hydrological observations made during our cruises, the existence of two different water masses distinctly stratified was easily recognized: (1) the upper layer from the surface to 75 or 150 m depth, (2) the lower layer below a depth of 75 or 150 m. The vertical distribution of plankton in the section accords it well.

The occurrence of the cold water forms in the deep layers off San'in district to Kyôga-saki, not too much distant from the coast, may be explained by supposing that the cold water-mass with low temperature and low salinity, originating from the North Korea Current descended deeply below the warm Tusima Current near Uturyô-tô and then flowed further southeastwards to the Japanese coast at the time of freezing. FURUHASHI (cf. Maizuru Marine Observ., 1952 b) found several cold water forms in the subsurface (0-50 m depth) water 14-20 miles off Kyôga-saki in winter (January, March and April). These cold water forms were found in more than 11.0°C (in March) to 13.0°C (in January), as cited above.

However, the vertical distribution of plankton seems to be not persistent throughout the year, but varies from time to time, since a diurnal or seasonal migration is to be expected. Furthermore, if a vertical migration of any animal tended to take place, very different conditions would be met with according to the rise or fall of water temperature (RUSSELL, 1933; CLARKE, PIERCE and BUMPUS, 1943; MOTODA and SATO, 1949). Therefore it seems likely that certain tolerant cold water species of cold current area or deep layer would migrate upwards during the cold season, showing no marked vertical difference in temperature as in the cold water. However, to determine this assumption more important and reliable data should be accumulated by continuous planktological and hydrological observations during at least 24 hours at selected stations of this area in the whole stage of plankton and in different seasons.

B. Horizontal Distribution of Plankton in Tango Bay and Maizuru Bay

Maizuru Bay and the inner part of Tango Bay (western part of Wakasa Bay) were dominated by the inshore copepods and diatoms in every cruise. These inshore forms gradually decreased towards the outer part of Tango Bay, and the poorest off Kyôga-saki, where offshore forms were fairly rich. In the outer area of Tango Bay occurred the admixture of the offshore and inshore species, and the offshore diatoms and animals were not so prevalent as in offshore waters off Kyôga-saki and the inshore forms were poorer than in the inner part and Maizuru Bay, as shown also by FURUHASHI (cf. Maizuru Marine Observ., 1952 c). In these bays and inlet, the plankton community is characterized by the predominance of inshore forms of *Chaetoceros*, other diatoms, animals and of larval forms. Following the method described in my previous papers of this series, some of the dominant species of copepods in relation to their local abundance may be recognized as indicators of hydrological conditions in these bays.

1. *Acartia clausi* and *Oithona nana* community.

In April the strictly inshore and estuarine species *Acartia clausi* and *Oithona nana* were very abundant in Maizuru Bay. The former species was more or less confined to the protected area of the bay, while the latter was widespread towards Tango Bay, though very scarcely in the area distant from the coast. Both species were associated with a large number of *Chaetoceros danicus* and *Ch. affinis* and other species of *Chaetoceros*, the nauplii of copepods, *Tintinnopsis beroidea*, *Tin. radix* and small number of *Paracalanus parvus*. Maizuru Bay is shallow and the water is highly stagnant, showing small transparency, lower salinity and higher value of water color in FOREL's scale than in Tango Bay.

2. *Oithona nana* and *Paracalanus parvus* community.

The plankton community of Maizuru Bay in July and in September as well as that of the inner part of Tango Bay was characterized by the predominance of *Oithona nana*, *Paracalanus parvus*, *Oithona similis*, *Pseudocalanus*, *Microsetella rosea*, *Acartia clausi* and *Tintinnopsis beroidea* in different frequencies of occurrence. Important phytoplankton associated with them were *Chaetoceros danicus*, *Ch. affinis*, *Ceratium oceanicum* var. *oblongum*, *Cer. pellucidum* in April, *Ch. peruvianus*, *Ch. compressus*, *Ch. didymus*, *Ch. van Heurcki*, *Ch. affinis*, *Ch. laciniosus*, *Ch. pelagicus*, *Ch. brevis*, *Hemiaulus sinensis*, *Thalassiothrix longissima*, *Ceratium furca*, *C. tripos*, *C. masciliense*, etc. in July.

and *Ch. Lorenzianus*, *Ch. didymus*, *Ch. laciniosus*, *Bac. hyalinum*, *Ditylum Brightwellii*, *Thalassiothrix Fraunfeldii*, *Ceratium furca*, *C. fusus*, *C. trichoceros* in September.

3. *Paracalanus parvus* and *Oithona similis* community.

Tango Bay was mostly occupied by the inshore copepods, such as *Oithona similis*, *Oithona nana*, *Paracalanus parvus*, *Microsetella norvegica*, *Micro. rosea* and *Oncaea*, of which the first two were the most abundant. *Oithona similis*, *Microsetella* and *Oncaea* appeared also in offshore waters in small quantities. This association apparently occupied a wider area in the bay in April and July than in September. The phytoplankton surpassed the zooplankton, both quantitatively and qualitatively, throughout the period and in all areas. The remarkable components of phytoplankton were as follows: *Chaetoceros laciniosus*, *Ch. affinis*, *Rh. setigera*, *Leptocylindrus danicus* and *Thal. Fraunfeldii* in April, *Ch. peruvianus*, *Ch. decipiens*, *Ch. Lorenzianus*, *Ch. van Heurcki*, *Ch. affinis*, *Ch. pelagicus*, *Rh. hebetata* f. *semispina*, *Rh. calcaravis*, *Bac. hyalinum*, *Climacodium Fraunfeldianum* in July, and *Ch. compressus*, *Ch. didymus*, *Skeletonema costatum*, *Th. Fraunfeldii*, *Cer. trichoceros* and *C. inflexum* in September. Besides, some offshore species, belonging to *Calanus*, *Eucalanus*, *Candacia*, etc. were found in small numbers.

Summary

1. The planktological and hydrological observations were made along the section between Maizuru Bay and New Yamato Bank on board the R. M. S. "Kurosio-maru" of Maizuru Marine Observatory during three cruises in April, July and September, 1950. The samples were collected by the cruise net from the superficial layer at all stations and also by the quantitative net for vertical hauls from 50, 150, 250, 400 meters depths respectively at several stations.

2. The settling volume and total number of plankton varied greatly at different stations and throughout the period. Their relationship was discussed in detail.

3. The quantitative and qualitative distribution of copepods, protozoans, cladocerans, pelagic tunicates, chaetognaths, larval forms, diatoms and dinoflagellates were studied. Their horizontal distribution showed a marked contrast between the offshore (off Kyôga-saki to the New Yamato Bank) and inshore (Tango Bay and Maizuru Bay) areas. In offshore waters, the plankton showed a marked stratified distribution in the appearance of the warm and cold water forms, the boundary between them lying on about 100 to 150 m layer.

4. In the section between Kyôga-saki and the New Yamato Bank, the warm water species of the Tusima Current occurred abundantly in the upper layer from the surface to 50 or 150 m depth, and some cold water species probably introduced by the southerly-trending submerged cold water of the North Korea Current were found only in the lower layer below 150 m depth except one station in the 50 m depth in April.

5. The cold water forms encountered hereabout were represented by 7 crustaceans, 1 medusa, 1 chaetognath, 1 tunicate and 1 pteropod.

6. Vertical stratification of the warm and cold water population apparently suggests the southeastward extension of the submerged Cold Current approaching the Japanese coast especially San'in district, but it may vary according to the diurnal or seasonal migration.

7. In the coastal area of Tango Bay and Maizuru Bay, three combined plankton communities in relation to the horizontal distribution of important copepods were distinguished: *Acartia clausi*—*Oithona nana*—*Paracalanus parvus*—*Oithona similis*. These communities were mixed from area to area and the center of distribution for each community gradually changed seawards in order.

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PHYSICAL ANALYSIS OF THE MECHANISM OF CELL DIVISION IN SEA-URCHIN EGGS¹⁾²⁾³⁾

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With Plate III and 2 Text-figures

Introduction

The history of studying mechanism of cell division has already passed more than a hundred years, but nothing has been clarified physico-chemically. Numerous observations in various cases have shown us contradictions and confused us by their complications. Up to this day, even the term "pole" in the dividing cell has never been known about its nature. Of course, no successful research has been done to know the cause by which the cell division is induced.

F. SCHRADER (1) has pointed out that the hypothesis which intends to explain each phase of cell division by force is nothing but the exposure of our ignorance about the physico-chemical nature of the cell, because even one of the reasonings on each phase can hardly be explained without any assumptions.

Indeed, numerous observations will be precious on some points of view, but if one can not understand the essential properties of component substances of the cell, the physico-chemical study of the cells will have no meaning. Therefore, we would not depend upon the view-points derived from the bases of the classical hypothesis. A new scientific method will have to be discovered.

Certainly, microscopical observations can not suggest us directly the forces by which the movement of chromosomes or other cell elements takes place.

But, we cannot ^{but} use the microscope because the size of the cells fits their visible ranges, so that the nature of the observing method must be reconsidered.

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2) Reported at the general Meeting of the Genetic Society of Japan, Oct. 13, 1950, held at Tokyo University.

3) Report of the Nippon Institute for Scientific Research on Pearls, No. 21.

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In general, the experimental method defines the meanings of data gained, such microscopical data tell us only the difference of the refractive index or wave length of light etc..

Our studies on the mechanism of cell division have to be based on the forces derived from a physico-chemical point of view. Then we must determine what methods are preferable to calculate the displacement by forces using only the microscope.

Fortunately, the author has found that a very primitive way to calculate them indirectly is left in some cases. At first, the standpoint on the analysis of the mechanism of cell division was reconsidered as follows.

1) Since fixed figures as artefacts are able to show us nothing about forces, the cells must be observed in a living state.

2) The phase contrast microscope may be the best one for such restricted observations.

3) The moving state must be photographed in continuous series with some intervals in order to make them put in a still state.

4) Microscopical data related with the force are only the changes of the length, in other words "displacement".

The length (L) relates to the volume ($V=L^3$),

and by BOYLE-CHARLES' law, $PV = nRT$

While the room temperature (T) and the medium pressure (P) are kept in constant in these observations, if the partial volume changes (dV) of the cell are observed, it must be considered that the outward pressure (P) of the protoplasm against the medium pressure at such points ought to be changed. Originally, the pressure means the thermal molecular movement.

However, a direct measurement of the change of P in these observations would be impossible.

Only the changes of (L) will correlate with the calculation as a result of P indirectly.

Actual principles of calculation will be shown in the following pages.

It has to be borne in mind that the changes of the visible structures are due to the cause derived from physico-chemical phenomena in colloidal dimensions and not in microscopical ranges. Therefore, it is obvious that this method cannot also give us the chance to intend the causal analysis of the cell division.

If actual data do not match with the result of the calculation, it is also obvious that this method must be abandoned.

Here, we shall have to determine what kinds of analysing method should be

possible. However, for this purpose, it is necessary to know the behavior of the cell itself in kinetic stages.

Preliminary Observation for the Bases of the Physico-Mathematical Analysis

Following three facts were observed preliminarily.

1) After the insemination, two main axes of the eggs changed their length gradually from round to ellipsoid until the deepening of the cleavage furrow began.

2) When the changes of both axes are proceeding, the separation of both centrospheres went on in the cell and then the cleavage took place along the short axis.

3) The cleavage surface had never been found as a plane. It was always shown as a bi-sphere just like two balls attached. Then the attached area of both daughter halves increased. While, in this phase, the second separation of the centrosphere had already proceeded, and moreover three axes of daughter spheres had gradually changed, it must be considered as the second ellipsoidal elongation. Then the second cleavage took place¹⁾.

This process was confirmed three times by different eggs of sea-urchins such as: *Anthocidaris crassispina* ('48), *Tripneustes gratilla* ('49), and *Mespilia globulus* ('50).

Above observations are able to understand as follows.

1) Some unknown internal changes took place in the egg by the fertilization.

2) The surface tension of the egg by which the shapes are held decreases; i.e. the round surface tends to the ellipsoidal surface with two different curvatures.

3) This surface deformation is naturally expected to give arise the migration of the inner elements. The main intracellular migrating element was the separation of the centrospheres.

4) It is easily supposed that the surface, decreasing its volume around the short axis, have to be unstabilized by its concentrated colloid substances. So, it will be understood that the bi-spherical furrow around the short axis appears. As long as the internal changes continue, the same process will have to be repeated. Accordingly, the second cleavage will take place in the same manner.

If these observations and understandings are correct, we can attain the following physico-chemical presumption.

1) Ref. E. B. HARVEY and G. I. LAVIN, Exp. Cell. Res., Vol. 2, No. 3., p. 398, 1951.

If the volume of the system is kept in constant, the deformation from a sphere to an ellipsoid will increase the surface area.

Thus unit surface free energy must be in constant because the medium pressure remains in constant.

Therefore, the total surface free energy tends to increase.

Would it be possible?

On the contrary, if a decrease in the surface free energy occurs, the increase of the surface area must take place. The ellipsoidal surface deformation must be a spontaneous increase of the surface area to repair the decrease of the total surface free energy.

No doubt the cleavage from a large sphere to two small daughter spheres is the latter case.

Observations and Results

MICROSCOPICAL STUDY.

Eggs used in this study are almost transparent under an ordinary microscope. But under applied phase conditions¹⁾, numerous small granules were recognized. In the unfertilized matured eggs, the nucleus was hardly seen in this phase condition due to its diffuse contrast.

Several minutes after the insemination, a dark contrasted region with no structures appeared clearly at the center²⁾. Then this dark contrasted region surrounded by the bright contrasted particles was elongated towards the long axis accompanied with the gradual surface deformation. Probably, this would be an initial spindle formation. As the low power of the microscope was used, the behaviors of other details could not be clearly observed.

This observation is not the morphological one in which the details of structures have to be studied. While the main problem of this study was the displacement, the oil immersion lens was not used for fear that it might not give us the data correctly by its suppression³⁾. But the details do not make any difference to me. The dark contrasted portion was enough to indicate the position of the cell element.

As the elongation of this region was going on, the midregion of it lost its contrast and only the terminal part of it was found to remain clear. Bright contrasted granules around this terminal part seemed to be arranged radially

1) 40×15 Bright Medium, Green filter Tiyoda Co. Tokyo.

2) This is an interesting phenomenon in colloid system in respect to the views of coacervates by T. HIROTA.

3) It is expectable that the radial arrangements of the cytoplasmic granules by suppression of the cover glass will occur. The astral figure will be intensified.

somewhat strained. It is supposed that these shapes will be identical to the centrosphere. The cell became the more ellipsoidal, the more the distance between centrospheres was seen to separate. When the axial ratio of the ellipsoidal egg attained about 8:11, the surface around the short axis became unstable and then the cleavage furrow began to deepen.

As was described in the preliminary result 3), it was confirmed that the cleaving surface was not a plane but a bi-sphere. Perhaps, this phenomenon would have been observed by many workers repeatedly, but no one suggested its physical meanings.

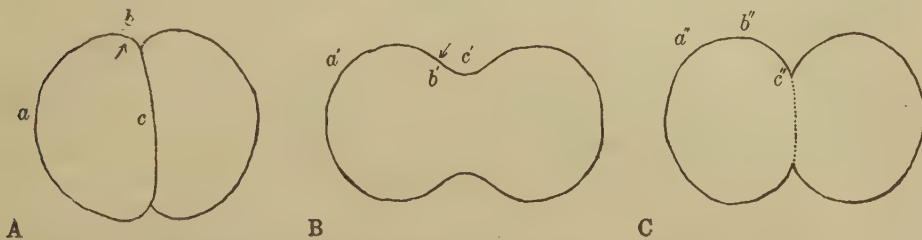


Fig. 1. The three types of the cleavage surface.

- A. (Bi-cup type). The curvatures of a , b , and c are not equal. It is difficult to occur as far as its surface tension is ^{not} decreased or suppressed.
- B. (Bi-lobic type). The curvature at a' is positive and that at c' is negative. b' is the bending point. Their surface tension at these three points must differ each other. This is also difficult to occur.
- C. (Bi-spheric type). a'' and b'' are almost equal in their curvatures but c'' is a discontinuous point. Furrowings is facilitated to occur at such unequilibrium points.

None of the three observations showed such a cut plane or a pulled bi-lobic surface, but always showed a bi-spherical surface (See Fig. 1, A and B). The term "cleavage furrow" does not fit to express this phenomenon exactly. The term "the cleaving spherical surface" and "the cleaved attaching plane" had better be used separately (Fig. 1, C). This is an important observation to suggest the physical properties of the cleaving surface.

RECONSIDERATION FOR MEASUREMENTS AND THEORETICAL CALCULATION.

In general, the volume decrease will occur due to the fertilization or other physico-chemical treaties.

Then we would consider the volume contraction on the short axis. If the slight volume contraction around the short axis takes place, the next inner layer must contract in the same way more or less in the higher rate. Concentrically, these contraction must affect to the central portion, and cell elements initially located at the central region have to move towards the long axis. In these

cases, the mean migrating direction of each particle in the cell must be perpendicular to the moving surface after the sign of P in GIBB's adsorption equation (2) (3). These considerations make the calculation of the displacement of internal elements corresponding to the surface deformation possible.

The displacement ratio is proportional to r'^{-2} (4); r' indicates the distance from the center of the surface curvature to the observing point on the main axis¹⁾.

This presupposition seems to be very rough, but it must occur decisively, if no disturbances arise in these processes.

For the determination of this view-point, the observing points were taken to answer the next questions.

- 1) Does the volume decrease really occur in the process of the cell division?
- 2) Do the changes of the length of both main ellipsoidal axes correlate timely with each other throughout the whole process?
- 3) Can the displacement of internal structural elements be calculated from the surface deformation?
- 4) Are the deepenings of the cleavage furrow independent from 2) and 3)?

The calculation was only facilitated with the point on both axes, but on the other portion it is permitted only as an approximation or an inference from the former.

For the above cited measurement, materials and methods were selected as described in the next section.

MATERIALS AND METHODS.

A) *Materials.* Sea-urchin eggs (*Mespilia globulus*).

B) *Method and condition.* Room temperature 26°C–27°C.

- (1) Observing apparatus. Phase contrast microscope (Tiyoda Co. Tokyo)

ob. 20 B.M. oc. 15×

Light source. 200 W, 100 V.

Filter for heat. 10 cm water filter.

Filter for wave length, green filter (Tiyoda Co.)

Intensity regulator. 10 am. slide dug.

Camera. Leica, Fuji F. panchro 35 mm.

- (2) Preparation. Eggs and sperm,—Natural breeding.

Insemination. Under the phase contrast microscope by an usual way.

1) $-\partial P/\partial A = \partial \gamma/\partial V \, dv = ds \, r^2/r'^2$

The sign of the term ∂P gives the direction of the pressure. ds , surface deformation. dv , displacement of the marked elements. r , radius of the surface curvature. r' , distance from the center to the marked elements.

(3) Continuous photographing. Exposure, 1 sec.

Timing, 30 sec.~1 min. for the quick phase.

5 min.~3 min. for the slow phase.

The usual observations were made at 30 V. (60 W). It was photographed with above-cited time intervals from the insemination to the cleavage.

C) *Measurement*. The long axis (a), short axis (b) of the deforming eggs and the distance between both centrospheres (c) were measured in each photograph. And moreover, the cleaving depth of furrows was measured (d). But the jelly coat layer was omitted in this measurement.

D) *Calculation*. Radii of the surface curvature at the top of the long axis are given in the next equation¹⁾.

$$r = b^2/a \quad \dots\dots\dots(1)$$

Calculations for the position of the centrosphere (c') are given as follows.

$$c' = ae = a - r \quad \dots\dots\dots(2)$$

Thus c and c' were compared.

E) *Other experimental condition*. The influence of the light was carefully minimized as sometimes the process was reversed by the higher temperature.

The effect of the the phase contrast was not at its best conditions. As the breeding condition was very difficult, it was necessary to keep the temperature of the sea water below 27°C..

ADDITIONAL OBSERVATIONS.

If the internal changes which give rise to the decrease of the surface free energy are continued, the bi-spheric daughter halves have to become attached bi-ellipsoids and may be appeared as a bi-cup shape.

Surprisingly, it was found that the second separation of the centrosphere has been proceeded in each attached bi-ellipsoid as seen in the first cleavage. If the third axis perpendicular to the observing plane in the bi-cup stage is able to observe from the pole, we shall find them changing.

It is evident from these observations that the first and the second division may have been proceeded by the same mechanism.

However, these are the reports of the observation which was gained only by eyes. Uncertainties and subjectivities cannot be swept off especially in morphological studies like this. Moreover, photographic evidence will sometimes

1) The radius of the surface curvature is given by the next equation.

$y = \sqrt{b^2(1-x^2/a^2)}$ but, $r = (1+y'^2)^{3/2}/y''$ so, $r = (a^2 - e^2x^2)^{3/2}/ab$
 but, $e = 1 - b^2/a^2$, $\therefore r = b^2/a$, at the top of the long axis,
 c' is given by $c' = ae = a - r$

be equal to the picture card which was brought back from an excursion trip.

Then, we must offer the result of the physical analysis from the foregoing principle D). Of course, this physical treatment must demonstrate directly the facts which were observed and understood in the preceding manner.

PHYSICAL MEASUREMENTS AND CALCULATIONS.

Main difficulties occurred from the differences of the egg maturity and of the duration time of dividing processes and moreover from the inconvenient, random occurrences of the cleavage plane. Each of them disturbed the determination of the starting point, timing and physical measurements, respectively.

The maturity was then assessed by fully rounded shape and the diffuse contrast of the nuclear region.

Since the time factor was eliminated from the calculating equation, the time intervals did not possess the absolute physical meanings. This is the most important fact in this analysis.

Gradual changes of dividing shapes were photographed by the adaptable timing to the proceeding velocities of each phase. Mainly, it was considered to

Table 1. Changes of the long and short axis, measured and calculated distances of the centrosphere and the depth of the cleavage furrow.

Photo No.	Long axis (a)	Short axis (b)	Distances of both centrospheres (c)	Calculated distance of centrospheres ($c' = a \times e$)	Depth of cleavage furrow (d)
1	19.5	19.5	0.0	0.0	—
2	20.2	18.7	1.60	1.82	—
3	20.6	17.8	4.60	5.28	—
4	21.1	17.2	6.70	7.06	—
5	21.6	16.6	8.50	8.89	16.4
6	22.0	16.3	9.60	9.94	16.0
7	22.4	16.3	10.00	10.53	15.0
8	23.1	16.0	11.70	12.08	14.0
9	23.6	15.6	13.20	13.70	13.5
10	24.0	15.7	13.70	13.82	11.9
11	24.5	15.8	13.70	14.32	11.3
12	24.6	15.8	13.80	14.44	10.0
13	24.6	16.0	14.20	14.45	9.4
14	24.5	16.0	13.70	14.45	8.4
15	24.4	16.4			11.0
16	23.7	16.5			13.4
17	23.2	16.7			14.2
18	23.0	17.7			14.8
19	22.5	16.5			15.6
20	22.3	16.5			15.6
21	22.5	16.3			13.8

catch the observing points continually.

Thus, the moving series of the dividing shapes were photographed.

Measurements were made from each photograph enlarged 2.5 times. The data measured and calculated are shown in Table 1. In this Table, a), b), c), c') and d) are the values discussed in the previous section C) and D).

The whole process finished in 30~45 minutes. No. 1~7 are the ellipsoidal surface deformation. No. 8~14 are the cleaving phase, the calculations in this phase are not accurate. No. 15~21 are a process of the second cleavage.

All the values are relative ones but not of actual length.

The interrelations of these values cited in the Table 1 are shown in Fig. 2.

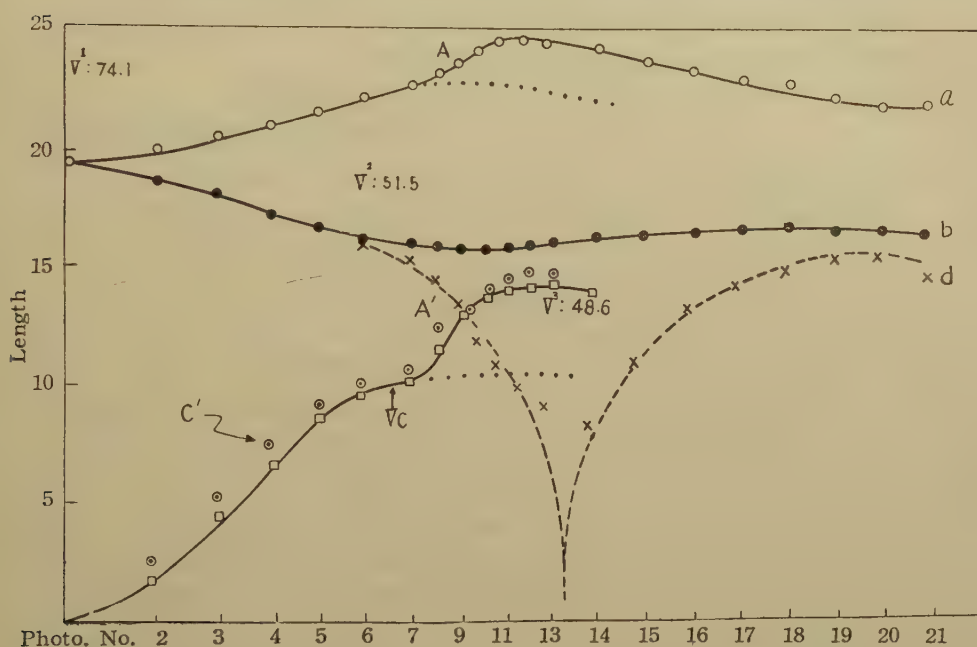


Fig. 2. Interrelation curves of various length shown in Table 1.

(a) Long axis, (b) Short axis, (c) Centrosphere observed, (c') Centrosphere calculated, (d) Attached area in cleaving surface, (V) The volume calculated from (a) and (b). A and A' show the irregular elevation of the curve.

If the pushing effect by bi-spheres does not appear, the dotted lines will be the normal curve expected.

Total volume of the egg in the cleavage process was calculated when it had the most regular shape. The values of the initial egg, of the ellipsoidal shape elongated maximally and of the bi-spheric shape, were given as 74.1, 57.6 and 48.6 respectively.

Obviously the values have decreased. The volume calculation was made by

the formula $4/3 \pi ab^2$.

Changes of the long axis (a) and short axis (b) showed a good correlation with each other timely. But the jelly coat layer was excepted from this measurements, because it was suggested that they may be an excreted layer (6).

We were particularly interested in the relation between the changes of both axes and the movement of the centrosphere. The displacement of the centrosphere was calculated through the next principle.

In the imaginal corn formed by the volume increasing surface and its center, the product of the surface displacement (ds) and its surface area is equal to that of the expected migration (dv) of the marked element and its localized surface area in the corn. So we will gain the next equation.

$$\begin{aligned} \theta \pi r^2 ds &= \theta \pi r' dv & \theta; \text{ solid angle of the corn.} \\ \therefore dv &= ds r^2 / r'^2 & r; \text{ radius of the surface curvature.} \\ & & r'; \text{ distance from the center to the marked element.} \end{aligned}$$

But we found in this case, $r' = c - (a - r) \neq 0 \therefore c' \doteq (a - r) = ae$

So c' is equal to the focus of the ellipsoid. Therefore, we are able to calculate the approximate position of the centrosphere shown in Table 1.

This is an important and surprising phenomenon in which the mathematical treaties are held strictly about the pole. It has been also found that such treaties are applicable in some other cases more complicated (4).

The irregular elevation A and A' in Fig. 2 make a good correspondence timely. The deepenings of the cleavage furrow (d) correspond to these elevation too.

The A' in the separation curve of the centrosphere is identical to the "pause" termed by H. Ris (5) in his anaphase study. The stage to the pause is the so-called anaphase and another stage after the pause must be included in the so-called telophase.

About the deepening of the cleavage furrow (d), it will be analysed in another paper. No. 7~13 show the depth of the bi-spherical cleavage furrow and No. 13~20 show the increase of the attached area of both daughter halves. Both ellipsoidal axes after No. 12 (a and b) have shown the reversal change. Of course, the third axis has been shortened and the second separation of the daughter centrosphere has also took place.

Conclusion

1) In general, we can not suggest the cause of cell divisions from these microscopical studies because the forces can not be recognized directly.

2) The about 30% volume decrease was observed in the process of the cell division.

3) The ellipsoidal deformation of the cell was ascribed to the decrease of the surface free energy.

4) The migrated distance of the cell element from the initially located position was calculated approximately from the changes of both axes of the ellipsoid and surface deformations. The results of calculations and measurements showed a good coincidence. In this case, the centrospheres were marked as the displacement elements in the cell.

5) The centrospheres appeared closely at both foci of the ellipsoidal egg. The pole of the dividing cell is not a mysterious center of the imaginal force but a physical center of the migrating cell elements at least.

6) It must be remarked that the cleaving plane showed always an attached bi-spheric type and never cleaved with a bi-cup shape. The latter is the following phase after the former.

7) The pause was observed in the migration of the centrosphere but it is able to be ascribed to the bi-spheric pushing effect.

Discussion

No more discussion about each part will be necessary, because each part has been explained with no assumptions. If any presumptions were introduced, the works should be done to demonstrate the assumption itself.

Although the late numerous observations are very valuable, the various explanations about the cell division derived from the imaginal force which was impressed from the morphological changes can not but be hypothetical.

Such hypothesis had never been proved their reliability. It may be inevitable, because the physico-chemical constructions of the cell were not understood enough.

The author was very interested in the anaphase study by H. Ris (5), since some conclusions were made in the same way (3) (4).

Any other data except displacement are not responsible as long as we are dealing with the force with the microscope in the living cell.

The migration force of chromosomes has been attributed to the imaginal activity of some structures in the passive state in the classical hypotheses.

Recently, an autonomous migration of the chromosomes has been suggested by some authors (1). The late hypotheses seem to have been asked the reconsideration by these observations. However, what method will be available

to detect whether the migration must be passive or autonomous?

Since the author had experienced that each case showed the gradual surface deformation, it had been studied that a reasonable spontaneous displacement of cell elements is accompanied with this deformation.

The cell membrane must be primarily treated as a physical boundary surface as far as the surface tension is effective to hold its shape (7), although a precipitation membrane or a denatured membrane will occur by its changed conditions.

As was described above, it is obvious that the bi-spherical cleavage surface may be a good evidence for the surface tension. It has been shown that the gradual surface deformation and the bi-spheric cleavage also take place in other cases (8).

Surface deformations suggest us the decrease of surface free energy.

But our microscopical studies are limited in respect to the changes of internal colloidal state by which the decrease of surface free energy occurred.

Then, if one portion of the cell surface which is composed of numerous colloid particles displaces in a slight distance perpendicular to the surface, the adjacent sublayer of this portion must be displaced with it in order.

If this expectation has been realized in the cell, the calculation which was described in the preceding section must be established.

As well as in this study, in the spermatogenesis of grass-hopper—the spindle elongation, the chromosome arrangement in metaphase, the chromosome migration in the anaphase, the behaviors of the mitochondria—there is found the fact that the same calculation is closely established (4) (9).

But the appearance of the chromosomes in the prophase, the disappearance of them after telophase and the formations of aster or fertilization membrane are the problems of the colloid physical changes (10) (10').

Therefore, the physical analysis of the coacervation will be able to answer for these problems (10).

Some interesting observations related to these problems were reported by several authors, i.e. surface granules and the fertilization membrane (11), the granular strand and astral formation (12), migration of basophilic granules (14) and mitochondrial behaviors (24) morphologically; other observations were made physically, i.e. the astral ray as a stream line (15) and as a streaming or a structural birefringence (13) (16).

On the other hand, the chemical analyses were made: Changes of the DNA contents after the fertilization (17), of amino acid composition of total proteins (18) (23), of free amino acid (19), jelly coat substances (20) and the electro-

constriction of amino acid by dissociation (21) (22).

These studies may be responsible for studying the cause of cell divisions, if they were confirmed systematically in the physical point of view.

The surface deformation had been pointed out several times, but no one calculated the migration of the cell elements from it.

In this paper, some natures of the dividing pole were characterized from this calculation. Although further investigations should be necessary, it is sure it may be a physical center of the protoplasmic streaming at least.

In addition to this, the reasons of the pause of the centrosphere were suggested from the migration curve of Fig. 2.

If only one reality in the complex natural scientific phenomena was truly analysed, other numerous phenomena will be solved from its same basement.

In conclusion I wish to express my deepest gratitude to the members of the Seto Marine Biological Laboratory who had conferred me suggestions and conveniences in carrying out these experiments and to Professor K. NAKAMURA who had encouraged on this study.

Summary

1) The physical analysis of the cell division by some sea-urchin eggs was attempted with the phase contrast microscope and the continuous photographing method.

2) The decrease of the total volume was showed evidently by calculations.

3) Changes of both axes and displacements of the centrosphere were measured when the ellipsoidal surface deformation was proceeding.

4) The results of the calculation about the position of the centrosphere showed a good coincidence with the data measured.

Therefore it was suggested that the cell elements may be displaced physically and some physical characters about the pole and the pause are clarified.

5) The surface of the cleavage furrow showed a bi-spheric shape and the bi-cup shape appeared in the next phase of it.

It was suggested that they may be resulted from a decrease in the surface free energy.

As the basal view-points, it has been held firmly throughout the whole work that the length is the only data gained physically.

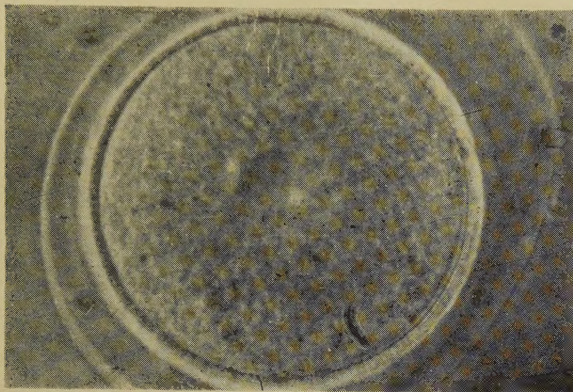
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EXPLANATION OF PLATE III

- 1) The dark contrasted nuclear region appeared soon after the fertilization.
- 2) An initial phase. 3) Elongated phase of the dark contrasted nuclear region.
- 4) Initial phase of the bi-spheric cleavage. 5) 6) the completion of the bi-spheric cleavage. 7) Bi-cup phase. Both halves attached gradually after the first cleavage. It will be seen that the second centrospheres have been separated.

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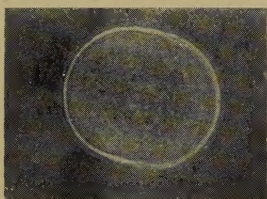
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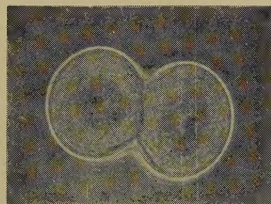
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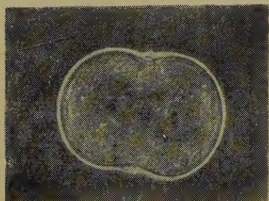
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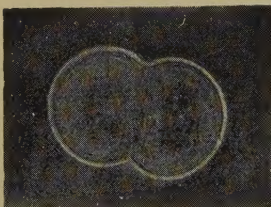
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